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ABSTRACT

This report shows how new technological tools or devices are being used in adult education and training; it examines the evidence of their effectiveness and costs; and it suggests prospects for the future use of technologies. Particular attention is given to uses with displaced and employed workers needing basic skills, high school diplomas, and skill upgrading. The technologies examined are broadcast television; cable; Instructional Television Fixed Service (ITFS); videotape; videodisk; computers (including computer assisted instruction, computer managed instruction, and embedded training); simulators; emulators; telecommunications; job aids; and "off-the-shelf" programs. In addition to discussions of each of the technologies, this report considers future hardware/software systems; settings in which the technologies have been used; the results of and need for more effectiveness studies; computer assisted instruction in basic adult education; adult students' need for social interaction; instructional design strategies; costs; barriers to and incentives for educational change; and lessons from previous attempts to integrate technological innovations in education. It is concluded that, although new technologies will come to play an important role in adult education and training, there is a great need for more research and systematic studies to demonstrate the value of technology based programs. The text is supplemented by 11 tables, 108 references, and a list of the names and addresses of 81 persons interviewed. (EW)

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Prepared for

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5 Oct 84

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THE ROLE OF TECHNOLOGY IN THE EDUCATION, TRAINING AND RETRAINING OF ADULT WORKERS

A Report prepared for
The Congressional Office of Technology Assessment (OTA)

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TECHNOLOGY AND TRAINING

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TECHNOLOGY AND TRAINING

EXECUTIVE SUMMARY

A central question today in education and training is whether and how new technological tools and devices, such as computers and video disks, can help improve the quality and reduce the costs of instruction. Because of its concern with the problems facing displaced adult workers and employed workers needing to prepare for second and third careers, the Office of Technology Assessment (OTA) called for a study to determine "whether traditional academic teaching (with lectures by a teacher and assignments for the students) and traditional vocational education (with practice on equipment similar to that found in the workplace) are the best or only ways to educate adults?" This report presents the answers that were found during the study.

The report shows how new technological tools or devices are being used in adult education and training; it examines the evidence of their effectiveness and costs; and it suggests prospects for the future use of technologies. Particular attention has been given to uses with displaced and employed workers needing basic skills, high school diplomas and skill upgrading.

THE TECHNOLOGIES.

The technologies examined are: broadcast television, broadcast, cable, Instructional Television Fixed Service (ITFS), video tape, video disk, computers (including computer assisted instruction (CAI), computer managed instruction (CMI), and embedded training,) simulators, emulators, telecommunications, job aids, and "off-the-shelf" programs.

Television — Of all of these technologies, television has been around the longest. There is no doubt of its broad impact on the American culture and its role in informing people and shaping their values. In direct instruction of adults it has had more limited success. The greatest virtue of television as an instructional medium is its ability to deliver instruction at a distance to individuals who for reasons of location, scheduling, physical capacity or inclination cannot attend regular classes.

Studies have indicated that students generally learn as well via television as through direct instruction. The development and delivery of televised instruction can be very expensive, particularly if an effort is made to emulate the production values of commercial television. When there are large enough numbers of students interested in a particular televised course, the cost per student can be very competitive with

classroom instruction. However, since such conditions are not very common, television has not achieved the use that its early advocates had anticipated.

Video tape and disk — Another disadvantage of television is that it is a passive medium with little opportunity for activity by the student or interaction with the instructor. Video tape and, even more, video disk give students a more active role because they can use the programs at times and ways under their own control, rather than being restricted by a broadcast schedule or preset sequencing and pacing of the instruction. When coupled with a computer they can provide a high degree of interactivity. In spite of the considerable promise from this combination, instructional use is still quite limited, in part because of the costs of equipment and course development, in part because not enough experimentation has yet been done on how to produce effective instruction with these complex media.

Computers — Of all of the devices, computers have excited the most interest for instructional applications. With their vast capacity for handling information, the almost infinite variety of ways that they can be programmed to respond to user commands, and their rapidly declining cost and increasing power, they seem to many to be the ideal "teaching machine." Taking advantage of these characteristics, thousands of teachers and courseware authors have produced computer assisted instruction (CAI) in almost every subject matter field. There have also been a few very large scale development efforts such as that which has produced the PLATO system.

In spite of the great promise, the controlled studies that have been done to date, of which ones involving adults are very few, have shown that CAI produces only small gains in achievement. Its most significant contributions are in the reduction in the amount of time needed for instruction and in holding quality constant when large numbers are to be taught the same material in differing locations. It is these features that have made CAI attractive to business and the military, since the time of students while in training is one of the largest components of the cost of training.

Another application is computer managed instruction (CMI). Management aids are particularly critical in any large scale effort to tailor instruction to meet the varying needs and abilities of individual students. When instruction is "individualized," it becomes a monumental task to track each student's progress through the differing possible paths in an instructional sequence and insure that the right lesson and material is assigned and available at the right time. CMI systems have been designed to assist with these tasks.

While CMI does help with the management tasks, there is no strong evidence that students in CMI programs perform better than students in more traditional arrangements. Because of the numbers of factors involved in assessing costs of such systems, it is also difficult to determine whether or not CMI is cost-effective.

Embedded training — Because microchips are being incorporated into so many devices that are being used by workers to perform their daily tasks (the word processor being only the most visible of many), it is becoming possible to use the power of the chip to "embed" training in the devices themselves. This is in a way a special application of CAI, except that instead of providing instruction in anticipation of need, instruction is provided when needed at the point of application. Indications from the businesses where such embedded training is being employed is that it is highly cost-effective even though the costs of the initial design are high. The economies come because one learns only what is needed to to do a particular task, with minimum time taken from the job, and little opportunity to forget or misapply the instruction.

Simulators and emulators -- When training on a real device or in an actual situation would be too dangerous or costly to provide for adequate instruction, simulators or emulators are used. Many of these now also use microchips. While flight-training simulators have conclusively proved their worth, there is still much debate about other simulators because of the mixed results obtained in the few systematic studies that there have been of their use.

Computer graphics -- One of the applications of computers that is coming into increasing prominence in instruction is computer graphics. Ours is a highly visually oriented society, thanks very much to television. With the cost of graphics devices rapidly coming down and their capacities going up, it is becoming possible to produce highly interactive, visually powerful, instructional materials that are beginning to be used in many areas from basic skills instruction to the advanced training of such diverse specialists as physicians, engineers and textile designers.

Telecommunications — Another of the technological developments that is finding a significant place in adult education and training is the increasing capacity to provide two-way communications, a capability missing from "traditional" television. Now with the increasing availability of audio, video and computer conferencing, this limitation is being removed. Each of these types of conferencing has its strengths and weaknesses for instructional use and these are now being explored in a number of efforts throughout the country.

Job aids -- One of the clear findings from this study is that complex and costly technologies are not always better when it comes to instructional applications. One of the indications of this is the development of job aids, which are often chosen as alternatives to training. Embedded training, described above, is one form that job aids can take. Other aids, provided in various formats, are designed to reduce the reliance on recalled skills and knowledge. Often used in conjunction with prior training, job aids are claimed to be cost-effective ways to insure effective performance on jobs in which specific skills are only infrequently called for.

Off-the-shelf-programs -- The training literature is filled with advertisements for programs using various media to solve a myriad of training problems. This study could not begin to examine this mass of material to determine the extent of use or what the evidence is for effectiveness. An effort to provide guidance in decisions on what to use has recently begun among the professionals in the training field.

THE SETTINGS.

The greatest activity in the development and use of technology for adult education and training has taken place in industry and the military. With some notable exceptions, schools, community and four-year colleges and universities have been slower to adopt new approaches. Perhaps the most significant development is the growing collaboration between industries and specific schools, colleges or universities to promote the transfer of the training function from the companies in which special systems have been devised to institutions that can provide for on-going training. "Partnerships" and "collaboration" are the watchwords for the developing relationships in the provision of training, particularly in areas of high technology.

THE STUDIES.

In spite of the long interest of the military in training technology, and the growing concern with effective training in business and industry, one of the major findings of the study was that there have been few systematic studies involving adult students comparing educational technologies with traditional instruction. The most extensive studies have been done by the military services and yet even these do not provide a solid basis for making decisions regarding the use of technologies. Part of the reason for the lack of studies has been the limited resources available for research in adult education and training; part has been the difficulty of finding situations in which the large numbers of variables that should be examined can be systematically studied; part has been the relative newness of

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most of the technologies and a significant part has come from the judgement by many in industry that controlled studies are not necessary to determine whether or not a particular training device or program is effective. "It clearly works or it doesn't," is a typical business attitude.

CAI IN ADULT BASIC EDUCATION.

This conclusion about the value of studies applies as well to the applications of CAI for adult basic education, a special interest of this study. Intuitively one might think that the computer would be an ideal device for assisting adults with low academic skills because it is patient, non-judgemental, private and can be offered in an environment totally different from school with all of its associations, in many cases, with prior failure. Yet the limited efforts to apply this and other technologies with adults who need considerable learning help, have as yet not lived up to expectations. In part this is because technology-based instruction usually requires more up-front funding than is available to programs seeking to serve this population; and in part it is due to the need of these people for lots of personal attention from instructors, which reduces the potential cost advantage of the technologies.

THE ROLE OF SOCIAL INTERACTION.

On this last point, one of the findings of the study was the importance of access to live instructors stressed by both trainers and students. The need for social interaction during learning probably explains why adults, when asked, still prefer traditional lectures to any media, although unfamiliarity with media undoubtedly plays a part in this preference.

INSTRUCTIONAL DESIGN.

Another factor frequently cited by interviewees in the study that might account for the difficulty of determining the place and value of technologies in instruction, is the limited attention often paid to the need for systematic analysis prior to the establishment of a training program. If an organization is not clear as to what changes in outcome or performance are to be expected from the introduction of any training program, it has a weak base on which to make decisions about which approaches are most effective. Proper design strategies, many urged, are more important than specific delivery systems or devices.

COSTS.

The most persistent question regarding the application of technology to training is the matter of costs. Although many users of technologies could give cost figures, because of the

lack of standardization in the way that costs and benefits are determined, little confidence can be placed in the available data. Costs for differing technologies vary widely, but there is general agreement that the "up-front" costs of technologies are almost always greater than traditional instruction. Beyond this, it is extremely difficult to generalize about costs and the economic value of the benefits from the differing approaches. Nonetheless, it is generally believed that the larger the numbers of students who will be receiving the same instruction and the longer the time period over which the program will be used, the more likely it is that technology-based approaches will be both cost-effective and insure consistency of training over the life-span of the program. There is not much data as yet to support these beliefs.

BARRIERS TO TECHNOLOGY IN TRAINING.

Because the costs of technology are going down and traditional instruction is going up, cost as a barrier to the adoption of instructional technology is going down. Two other barriers are likely to be somewhat more resistant to rapid change: the attitudes of managers and faculties and the continuing lack of effectiveness of many of the programs. The growing availability of computers may help significantly to reduce both of these barriers in the next few years.

LESSONS FROM HISTORY.

However, the history of efforts to introduce technology into instruction are not encouraging for the future. The histories of programmed and individualized instruction and even film may help both temper extravagant expectations from any particular technology and, at the same time, indicate that considerable progress is being made in understanding the underlying learning and instructional processes that must be mastered before any technology will be effective.

CONCLUSIONS.

Thus the answer to the original question posed by OTA is that there are alternatives to the traditional forms of adult education and vocational training, but it is too soon to say yet which of them are going to prove to be most effective, acceptable to students, instructors and institutions, and economically viable. There are a number of conclusions from the study in which a high degree of confidence can be placed:

1. No single device or technology will be the answer to all training needs. Those needs and the variability of individuals is too great to expect that any one approach will fit all.

2. Some technologies, particularly those employing microprocessors, will make major contributions to the improvement of instruction.

3. Large investments in development and experimentation will have to be made before those benefits are widely realized.

4. The most effective use of devices for instruction will be in situations where the device itself is the object of instruction, as when computers are used to teach the use of computers.

5. Live instructors will continue to play an important role in instruction, particularly in helping those adults with the greatest difficulty in becoming self-directing learners.

6. The development of effective applications of technology to the instruction of adults will benefit from extensive dissemination of successful practices and from policies both at the institutional and governmental levels that recognize the critical importance of the investment of up-front time and money.

7. Systematic studies to demonstrate the value of particular programs, devices and training strategies will help improve decision making regarding training technologies, but there are no strong incentives for organizations doing training to produce such studies, and their absence will not be a significant barrier to the further introduction of technologies in adult training and education.

I. INTRODUCTION.

A central question today in education and training is whether and how new technological tools and devices, such as computers and video disks, can help improve the quality and reduce the costs of instruction. Because of its concern with the problems facing displaced adult workers and employed workers needing to prepare for second and third careers, the Office of Technology Assessment (OTA) called for a study of that question with specific focus on adult workers. It asked "whether traditional academic teaching (with lectures by a teacher and assignments for the students) and traditional vocational education (with practice on equipment similar to that found in the workplace) are the best or only ways to educate adults? The purpose of this report is to present the answers that were found to this question.

The answers presented were obtained through interviews and an extensive literature review, much of it done after a thorough search of on-line databases.

Over one hundred persons were interviewed, representing a cross-section of knowledgeable people in the field of worker education and training. (See list in appendix.) These are, obviously, not all of the experts in the field, but what they had to say to us gives a reasonable picture of the state of the use of technological devices and approaches in the education and training of adult workers. From them we learned about what is and is not being done, what studies have been conducted, and we received varying amounts of detail on specifics of applications and costs.

The report is a summary and analysis of what we learned from the interviews and literature. It attempts to steer a course between the Scylla of sweeping generalizations to which we are tempted by the nature of the material and the Charybdis of anecdotal recitations to which we are drawn by the same material. To find the proper channel through these shoals, we will combine summaries of the descriptive and analytical material with critiques of their significance for understanding the state-of-the-art.

There are two important gaps in the information:

1. One results from the state of the field itself. As we shall indicate, there are few of the kinds of systematic studies that everyone would like to have that would provide a solid base for deciding what works and what does not with specific learners, to achieve specific outcomes, in specific settings and at what costs and with what benefits.

2. The second gap results from an incomplete pursuit of information that is available. We did not have the resources or time in this project to follow-up on all of the leads that we received. We believe that we have given a comprehensive overview of the current status of knowledge concerning the uses of technology in adult education and training. We know that we have not covered all of the uses of technology for that purpose nor identified all of the hundreds of programs or projects that are using various forms of technology.

We trust that this report will be useful to the staff of the Office of Technology Assessment as it explores the larger issues that constitute the context in which this study will be used.

II. TECHNOLOGICAL TOOLS.

The descriptions that follow are derived from a variety of sources: published materials, interviews, and our own experience. Since most of our information comes from particular settings, most of the description will be situation specific, with sufficient information provided so as to help determine the extent to which the experience might be generalizable to similar settings. Wherever the programs are designed to serve displaced workers needing basic skills, particular attention will be given to how and how successfully this is done.

Following each description there will be a critique of the program and some indications of its broader implications. In later sections of the report these implications will be synthesized and, where possible, generalized.

A. TELEVISION (including broadcast, cable, ITFS and video tape)

Television in its various forms is the most well-known and widely used of the newer technologies. As a broadcast medium, whether through the air or via cable, it is capable of bringing instruction to large numbers of people who might otherwise not be able to receive it. If the numbers who receive the program are large, television can be one of the least costly means of delivering instruction.

In one sense, of course, television is not an "educational technology" but only a means of delivering instruction without the student and instructor needing to be in the same location. However, in addition to being a delivery system, television does make it possible to do some things that cannot be done by a live instructor, such as enlarging images, displaying together things or events that do not occur naturally, slowing or speeding events, and, most important, permitting replication of the same content and quality over and over. For those reasons, and because television is commonly treated as a form of instructional technology, we will discuss it here.

The central feature of television is the capturing of an image electronically and either transmitting it directly or storing it on a medium such as tape or disk. Whether the image is transmitted from microwave towers, through cable, or via satellite or stored and then transmitted or displayed on a cassette or disk player does not basically make a difference so far as the content and, to a large extent, the quality of the message is concerned. However, because each mode does have some advantages and disadvantages for instructional purposes, and differing cost implications, we will discuss applications of the various forms that the television image can take.

In the 1978-79 Higher Education Utilization Study conducted by the National Center for Education Statistics, 25% of responding colleges and universities reported some use of television, but only 14% used it for off-campus instruction, where, presumably, it would have served mostly adults. During the Corporation for Public Broadcasting's first year of its adult learning service, telecourses offered by 555 colleges and universities were taken by over 50,000 students.(1)

While the focus in this study is on the uses of technology primarily for training adult workers, it is important to note the potential size of the adult learner audience. Peter Dirr from CPB estimates that, for some of the popular telecourses "there are often 100,000 informal learners (i.e., nonenrolled viewers) for <u>each</u> enrolled student." The numbers for "Cosmos" were approximately 10 million. "This number, Dirr points out, "is almost equal to the full-time equivalent enrollments in higher education in 1980!" Moreover, he adds, "there are 58 million persons in this country 25 years of age or older who have completed high school but who have not completed college and are not now enrolled in college."(2)

In the early days of televised instruction, numerous studies were done to compare the effectiveness of television with traditional classrooms, almost all at the elementary, secondary and collegiate levels since, in those days, television was not as yet much used for adult education. After a review of some 420 of these studies, Chu and Schramm concluded that in almost all cases there was no significant difference in learning outcomes. Differences that did show up could usually be accounted for by other factors.(3)

The judgement regarding television that we heard repeated many times is that, given a choice, students and instructors would prefer live instruction; but that if the choice is television or completely independent study, most people prefer television. For this reason colleges, particularly community colleges, have used television to reach off-campus students, who are usually adults, with a wide variety of programming. Development of adult education courses has been fostered by the Adult Learning Service of the Corporation for Public Broadcasting.

However, in spite of the potential and the activity of so many colleges and universities, there have been "glaring failures," according to Jerold Gruebel, executive director of the West Central Illinois Educational Telecommunications Corporation. He writes:

> The long-running Sunrise Semester association between CBS-TV and New York University has come to an end. The University of Mid-America has collapsed. The Appalachian

> Community Service network is in danger of being liquidated. The National Association of Educational Broadcasters, which fostered televised instruction, has folded. The American Education Television Network failed miserably, and the National University Consortium continues to struggle.(4)

The primary reason for these failures has been the inability of instructional television to garner an audience willing to pay for instruction via television large enough to cover the costs of production and delivery. Many of the courses offered by, for example, The University of Mid-America, simply did not get the tuition-paying enrollments that the sponsoring institutions required in order to support the programs. Often with televised courses, sponsors say that the numbers who view the courses but do not enroll are larger than the number who enroll. Only when offerings are underwritten, can such non-paying learners be served, and the institutions mentioned by Gruebel did not have enough of such underwriting to serve a general, non-paying audience.

There have, of course, been successes and some of those will be described below.

One of the leading scholars in the field of adult education, Patricia Cross at Harvard, has also examined the role of television in adult education and found that a very large proportion of colleges and universities were using television for on- and off-campus instruction. In the latter category she found, for example, that "in the profession of law alone, some sixty thousand attorneys in California are using videotapes to keep abreast of new developments in their profession." Commenting on this development, she wrote:

> Thus, it may be that apologists for the instructional potential of television and video cassettes should cease their preoccupation with explaining why the media are not well received and begin to look at the potential impact of increasing familiarity on the use of media in education. As the children of the electronic age experience the use of television in schools for educational purposes, they may come to prefer it as adult learners.(5)

While a year or two is hardly enough time for aging process to occur, the results of a nationwide survey of 2000 adults reported by Aslanian and Brickell in 1980, show that only one percent of the 744 persons who said that they had done some formal study during the year were using broadcast television as a source for learning. The survey did not ask what they were studying or about other media.(6)

Another form of television is Instructional Television Fixed Service (ITFS). It is a low-power, all-directional broadcast system with a direct, line of sight reception area of about 20 miles. One of ITFS's chief virtues, in contrast with broadcast television, is that it is inexpensive. Equipment costs about $2000 per location. Because of the weak signal, there can be many ITFS stations in the same area as a single broadcast station. Each station may have up to four channels and there a two-way audio capability which may be used for student-faculty interaction.(7)

The advantages of ITFS have been explained by Mina Ghattas and Michael Theall, director and researcher, respectively, at Northeastern University:

> ITFS is a unique vehicle for the delivery of information and services to audiences whose existence has been well established (e.g.: businesses seeking specific continuing education course offerings). ITFS provides these services at reasonable cost (i.e., less than other telecommunications delivery systems with equivalent or lesser capability).(8)

Table I, reproduced from the Ghattas and Theall paper, compares ITFS with other technologies. Although arguing for the present value of ITFS, the authors foresee a time very soon when other technologies, such as interactive cable, direct broadcast satellite, and other networking systems will offer cost effective delivery systems to serve the same functions as ITFS.

Another delivery mode for the television signal is cable. Some cable companies do offer instructional programs, but as Dirr notes, "of the 4,600 cable systems in existence at the time of our study (1978-79), 80% (3,680) were six- or twelve-channel systems, which were hardly capable of providing a very wide range of services. Even in 1982, when more than 5,000 cable systems were in operation, close to 60% were still six- to twelve-channel systems."(9)

As more cable systems expand their capacities to 20 or more channels, introduce two-way capability, switch to fiber optics to improve quality and lower costs, and enroll more households, cable will become an increasingly attractive medium for instructional delivery.

Finally, there is the availability of satellites for instructional delivery. As we said above, the satellite is not an instructional technology in its own right, but rather another means to deliver the television image. However, its potential importance should not be overlooked, for reasons given by Harold Rice, vice president for Video/Audio Services and RCA American Communications:

Table I.
COMPARISON OF INSTRUCTIONAL TELEVISION FIXED SERVICE (ITFS) WITH OTHER DELIVERY SYSTEMS.

Communications Technology	Analog circ.	Digital circ.	Real-time cap.	Easy user access	24-hour availability	Multi-channel	2-way voice	2-way video	Privacy	Economic practicability rating*	Usefulness rating*	Applicability to educational, rehabilitative, medical and social services progra distribution.
AM Broadcast Stations	yes	no	yes	no	yes	no	no	no	no	C	D–	Meets few of the educator-specified requirements for a telecommunications delivery system.
FM Multi-plexed Circuits	yes	yes	yes	no	yes	no	no	no	yes	B	B	Useful for some applications: such as teletype circuits for the deaf; audio circuits for the blind; slow-scan TV fo educational purposes.
Videocassettes/ Audiocassettes	yes	yes	no	yes	no	yes	no	no	yes	B	C–	Useful as a storage medium; does not provide real-time access; has limited privacy; requires additional delivery system to reach student populations.
Public Broadcasting	yes	no	yes	no	yes	no	no	no	no	D	C–	useful only for general information on distribution; no privacy; excellent med for cultural development/enrichment programs.
Normal Telephone Circuits	yes	no	ye	yes	yes	yes	yes	no	yes	A	C–	No video, no digital capability; but us ful for non-video distribution and stud talk-back circuits in audio-video-out systems.
Special Phone Circuits	yes	yes	yes	yes	yes	yes	yes	yes	yes	D	D–	Wide-band circuits often not available; usually costly when compared with ot media circuitry.
CATV Circuits	yes	yes	yes	yes	yes	yes	yes	yes	yes	B	B–	Not available in many geographic areas often does not have 2-way capabilities which can be costly when available.
Satellite Circuits	yes	yes	yes	no	yes	yes	yes	yes	yes	D	C–	Equip. costly, not easy to install/opera useful for single channel dist. to sparse settled areas. Req. 5-6 times other med frequency spectrum and dollars.
ITFS Circuits	yes	yes	yes	yes	yes	yes	yes	yes	yes	A	A–	Only available methodology capable o meeting all educator-developed system specifications.

From J.A. Curtis, "Instructional Television Fixed Service: A Most Valuable Educational Resource." In J.A. Curtis and J.M. Biedenback, eds., Educational Telecommunications Delivery Systems (Washington, DC: American Society for Engineering Education,

*A=Good C=Poor
B=Fair D=Not useful

6.a Table I. To follow page 6.

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> Education and training by satellite is a national resource. No other distribution tool theoretically can reach the entire nation (he might have added: and the world) at such a low cost. But at the same time, we must realize that corporations will accept the satellite as an education distribution method only if it proves economically justifiable. And we must realize that employees will only accept satellite-distributed material if it is part of a professionally prepared and delivered package of learning.(10)

While the numbers that can be reached by a live broadcast is theoretically very large, scheduling often limits the numbers who actually view any presentation. The numbers reached can be increased by using video tape or disk. These modes allow students to use the material on their own schedules and to stop, start and replay segments at will. Disk and tape do require equipment that is not always available to adult learners.

Adult education has seen the full range of applications of television. The simplest use has been to put one or more cameras in a regular classroom and distributing the unedited result either directly over the air or via tape. At the other extreme there have been the elaborate course productions of the BBC, the British Open University, and those being funded by the Corporation for Public Broadcasting.

We have not attempted to identify all of the uses of television to meet the learning needs of adult workers but only those where it is being specifically used for displaced workers, or is making what appears to be a unique contribution to solving common training problems, such as in the continuing education of field engineers. The following are examples of some of the applications that we found:

Wayne State University.

One of the most extensive efforts to serve displaced workers via television has been the College Cable Network Project, a collaborative venture of Wayne State University and WTVS in Detroit, Michigan. The United Auto Workers was actively involved in the development of the program.

Started in 1973, the original concept of the project was to provide opportunities for working adults to earn college degrees without having to take long periods of time off from work. Courses were designed to be delivered via television and through classroom sessions conducted on week-ends, which resulted in the program being called a "Week-end College." Initially there were only 60 full-time students enrolled. Some 15,000 workers have taken courses and over 2000 have graduated. The

students have to meet the same examination and other requirements as regular college students. Currently there are 400 students enrolled full-time and 1000-1500 part-time in credit courses.

In addition, this fall, the program is seeking to reach some 4000 unemployed workers, many on welfare, to encourage them to use Pell Grants and tuition grants from the automobile companies to which they have access. to enter the degree program.

When the heavy layoffs hit the auto industry the focus of the program shifted somewhat from a degree emphasis to meeting some of the more immediate information needs of displaced workers, such as for information on job availability, career planning and skill training. This program was developed by the College Cable Network of Channel 56 in Detroit.

This program provides job orientation and support for several thousand workers using cable television on a 24-hour a day basis, with opportunities for students to come to learning centers to meet with instructors and each other. Delivery of material for broadcast on the many cable systems involved in the project is via ITFS. This is done to keep distribution costs to a minimum.

In 1978 other colleges were invited to join the program. The To Educate the People Consortium was formed which now includes more than 25 institutions. Courses are delivered via satellite to them." The Consortium offers baccalaureate degrees, with special emphasis on topics of special interest to workers, such as the history of unions, economics, and organizing strategies. Much of the material use was developed by Wayne State.

Discussion.

No systematic study has been done of the students in the program in comparison with traditional students. However, project administrators claim that there are no indications of differences in learning or retention although they do say that regular contact with faculty seems to be a key factor in student retention. Providing such faculty contact does significantly increase the costs of the program and reduces the cost advantage of television delivery. In order for the program to be cost-effective there must be large numbers of participants; to achieve large numbers there must be constant effort on the part of program administrators to make the program known to potential participants.

A key to the whole effort, according to director Otto Feinstein, is changing the culture of the workplace so that both workers and employers support the value of continued learning.

However, Feinstein argues, even if the costs are high, the critical question is the value of providing educational opportunities to people who would not otherwise have them. In his view, it is not the technology, but the provision of accessible opportunities that is key to meeting the needs to workers both before and after they have been displaced.

Today the entire operation of the program is funded out of tuition income. One of the battles with the University that he had to fight, says Feinstein, was to retain all tuition income for the program. "Only in this way can programs that serve non-traditional students become self-supporting."

Oklahoma State University.

The use of television by John Jobe at OSU is very different from the Wayne program. Jobe uses video tape to provide remedial tutorial instruction on specific math problems that students encounter during their courses. The programs are not course lectures, they are tutorials. The students use them on an independent, voluntary basis only when they need to learn how to do something that they did not learn during the regular classes.

The tapes are produced by videotaping actual tutorial sessions. With each tape there is supplemental print material which the student is expected to use.

Jobe has produced over 300 thirty-minute tapes with accompanying print materials. They are available to students on campus in the TV lab and are, according to Jobe, heavily used. They are particularly welcomed by older students who often have trouble with some of the math concepts that come more easily to younger students.

The cost per module is highly variable but averages about $1000.00.

Discussion.

Jobe has not done any systematic study of the effectiveness of the modules. He relies on the indications of heavy student use to establish that this use of television is effective. As a further indication, the publisher, Addison-Wesley, is having Jobe produce tapes as a supplement to a new math textbook.

ITT Telecom.

A somewhat similar application of television is used for worker training by George Harmon, Director of Personal

Development at ITT Telecom. Here television is also used for tutorials but, in this case, the production of video tapes is more elaborate than at OSU. When a training need is identified, Harmon selects an appropriate subject-matter specialists either from within the company or outside. The expert conducts a tutorial with one student. Three cameras from differing angles capture images of the session. Those tapes are "source documents" from which a final tape is prepared. If the content is acceptable but the presentation is not, a professional actor may be used to produce the final tape.

Discussion.

Harmon went to this approach because his experience in training had shown that while one-to-one tutoring was by far the most effective training method, it was also the most costly. The taped tutorial enabled him to capture the expertise of the content specialist with a minimum cost in time and money; while the editing and remake allowed him to produce an effective instructional program that would be used by the people for whom it was intended. The intended users are in plants throughout the world which would have made bringing the specialists and the students together prohibitively expensive.

This evident advantage is so great that Harmon sees no need to compare the results of the video taped with regular instruction. He does, however, claim that users of the tutorials can gain as much as students in classes in one-fourth the time.

University of South Florida.

The College of Engineering, like other engineering colleges (Stanford, Northeastern, University of Massachusetts), has recognized the need of practicing engineers for continuing education. Because these people cannot easily come to campus, the college delivers courses to them via ITFS and tape. Over ITFS the courses are beamed live to remote sites in the Tampa area. There is two-way sound so the students at any location can interact with the instructor.

For those that cannot meet the live schedule, the same material is distributed via tape but without, of course, the opportunity for immediate interaction.

However, even in the .ive remote locations, there are limitations on the amount of interaction that can occur between students and instructors. For example, it is difficult for instructors to know how students s/he cannot see are responding to the lectures. To overcome the problem, Dean Andrew Barrett and his colleagues in the College of Engineering have devised a "magic box" that permits an instructor to get the same feedback

from students regardless of whether they are in the classroom or at a remote location. The box is connected to each student location by telephone. When the instructor asks for a response, each student enters his/her response on a keypad. The results are instantly displayed to the instructor, who can then see if there are any differences in response that are dependent upon location of the students.

The same system can be used to distribute quizzes and transmit homework from the students to the instructors. In the latter application, the students do their homework on computer disks, which are inserted in a transmission device at each location and sent to the instructor's machine. There s/he can correct it and return it via the same channel, thus greatly reducing turn around time and paper handling. An addition being worked on would enable students to use the system even if they are receiving the course via tape rather than live.

Barrett hopes to see this system used in all remote locations by January, 1985. "Such a system," he said, "assures delivery of high quality instruction to any business site in the State. This," he emphasises, "is an important factor in drawing high technology industry to the State."

Discussion.

"I would prefer live instruction," said Barrett, "but, since that is impossible, television is a better alternative than nothing. It is critical that we provide opportunities for continued learning for our engineers whose knowledge becomes obsolete in 4-5 years."

To make remote delivery cost-effective Barrett needs to increase the numbers being served. To achieve that objective, the college has formed a consortium with other institutions in the State and hopes to do the same on a nationwide basis. They would like to create a satellite network with full two-way capability, but up to now the cost of transponder time has been a barrier.

Northeastern University.

In 1983 Northeastern began using ITFS to deliver graduate level engineering courses to professionals in Massachusetts and New Hampshire. The courses are sent during the day to nine area electronic and electrical companies at 13 sites. The service offers one-way video and two-way audio which allows the students at remote locations to communicate with the faculty. This year the service will be delivering 80 courses.

The University has joined with 14 others to form The National Technological University (NTU). The NTU offers

televised courses in computer engineering prepared by seven of its members. Among the courses which will be offered for the first time in Fall 1984 are Software Engineering, Error Correcting Codes, Advanced Computer Architecture, Introduction to Artificial intelligence and Interactive Computer Graphics. Participating universities in addition to Northeastern are Colorado State University, where the headquarters for NTU is located, Purdue, Georgia Institute of Technology and the Universities of Maryland, Massachusetts, Minnesota and South Carolina.(11)

Discussion

See the discussion of ITFS above.

City University of New York.

Concern with students who are place bound because of limited mobility or limited resources, Lee Cohen, Director, Institute for Research and Development in Occupational Education, has looked at low-power two-way television as an inexpensive way to bring courses to people in a geographically limited area. The basic equipment for broadcast purposes is only about $1000. By creating a network with other colleges, resources could be shared and people served who would not otherwise be.

Discussion.

In spite of the low-cost and ease of use of low-power television, Cohen has not yet been able to get anything but very limited experiments started.

Army Health Services Command (HSC).

The HSC at Fort Sam Houston, Texas, has used a satellite since 1979 to help educate personnel around the world. Two daily network programs are broadcast on various medical subjects. One is directed toward enlisted personnel, the other to professionals such as doctors and nurses. The programs include two-way telephone communication during the live broadcast.(11)

Discussion.

This program illustrates the capability of using satellites to reach people widely dispersed over the nation or the world. The report did not, however, indicate how the program handled the time-zone differences, particularly during the interactive portions of the program. Given the costs of satellite transmission and the limited availability as yet of ground receivers, it may be that only the military can afford this system at the present time. It is to be hoped that studies

are being done of the effectiveness of live and two-way transmissions in comparison, for example, with the use of tape or disk for distribution of the basic material, with audio conferences occasionally to get the two-way interaction.

B. VIDEO DISK.

We treated video tape as an extension of broadcast television because, essentially, it is a linear presentation mode with only limited opportunities for student interaction. There have been systems developed to permit random access to tapes but these systems are cumbersome in comparison with the video disk.

Ever since the development of the video disk in the early seventies it has excited many educators looking for a technology that would combine the visual power of television with the interactivity that they all recognized was missing from broadcast television. Yet in spite of the apparent promise of this technology, the promises have yet to be met. In looking for technologies that work in education and training, this example is particularly instructive.

The features of video disks that have excited educators about its potential are:

1. Random access capability. Any frame on a disk can be found in under five seconds. (In contrast, the maximum search time on a thirty minute tape can be 3.5 minutes.) This means that all of the information on the disk can accessed by the learner or by a computer program that selects the next frame to be displayed based upon the student's previous actions.

2. Information density. A single side of a disk has 54,000 frames, with sufficient resolution so that each frame can present readable written text or very high quality graphic or pictorial images. (The resolution is 350 lines per inch in contrast to tape's 250 lines.) Viewed at the rather fast rate of one image per second, it would take 15 hours to view all 54,000 frames. This means that a huge amount of visual information can be stored on a single disk.

Because of the density of the storage on a disk, if textual rather than visual information is recorded, the entire text of the 30 volume Encyclopedia Britannica could be stored on merely four percent of the disk's surface. The disk really should be thought of as a convergence of all media, not simply as a videotape on disk.(13)

3. Durability. Because in laser disk players there is no physical contact with the disk, there is virtually no wear. The disks themselves are made of durable materials that are relatively impervious to abuse.

So promising was this technology that one of the earliest developers, Alfred Bork, Director of the Educational Technology Center at the University of California at Irvine, in the early seventies dubbed the combination of the video disk and the computer as the "intelligent videodisc."(14)

In 1977 Andrew Molnar and Dorothy Deringer of the National Science Foundation reported on a conference organized by Bork on "Intelligent Videodisc Systems for Education". While suggesting the great potential for education, they concluded that "preliminary research and development is needed before judgments can be made as to the significance of this technology in education."(15)

The most recent survey of the implications of the video disk for education cites numerous endorsements of the wonders of the disk, concluding with the view of R.K. Wood and R.D. Woolley in a 1980 NIE report that, "The impact will be equal to or greater than that of print technology some 500 years ago."(16)

In spite of the potential of this technology and the enthusiasm of its proponents, it has yet to make a significant impact in education or training. To be sure there have been interesting applications. Ford and General Motors provided disks and players to each of their dealerships for use by salesmen, customers, and mechanics.(17)

The Defense Department has developed video disk-based simulators and used them in tank gunnery training, flight simulators and maintenance training.(18) JAM, Inc., a video disk production firm in Rochester, NY, has produced interactive disks for Wang, Kodak and Rochester Institute of Technology. WICAT, a development organization in Orem, Utah, has made extensive use of interactive video disks in its training programs for industry. We did not encounter any applications of video disks in remedial education.

One of those industries is AT&T Information Systems in Parsippany, NJ. Al Cohen, director of the Service Division, described the three modes in which they have been using interactive video:

1. Full motion and sound. The only student control is starting, stopping and moving about in the program.
2. Still frames with text. Here there are "maps" on the screen so that the student can move around to find just the portion required.
3. Pages of text only as source documents. With an index accessing system, this provides information only when needed.

Cohen says that thus far they have only done informal studies but they seem to indicate that interactive video disk programs "cut teaching time by 50%."

The International University Consortium for Telecommunications in Learning (IUC) has released the findings of a 1983 Videodisc Feasibility Study. The evaluation showed that the technology is a cost-effective alternative distribution system for the video components of IUC courses. It is feasible as an alternative means of program distribution as well as being a valuable teaching aid for faculty.(19)

Despite all of the apparent advantages of interactive or "intelligent" video disks and the interest of many developers in their use, Cynthia Schuyler reports that "in many training and educational circles, the new technology, initially hailed as the ultimate training medium, was branded as a loser." The reason according to Schuyler and many others is cost. An interactive playback system costs between $2000 and $15,000 and production costs for a single disk can run from $50,000 to $400,000. (See below, Chapter X, for a further discussion of cost factors in video disk simulations.)(20)

Another factor is the interaction of the availability of playback equipment and courseware. People won't invest in the equipment unless there is something useful to do with it; courseware producers won't invest in development unless there is a market for it. Schuyler"s sources, especially a report from a business research firm, suggest that 1984 may be the year when the "critical mass" on both ends comes together.(21)

However, it may not be just cost and the hardware/courseware connection that has prevented full development of this medium. As Molnar and Deringer said back in 1977, "research and development is needed" and not much of that has yet occured. Further, as Schuyler discovered, "from the point of view of trainers themselves, the promise offered by interactive video is still not altogether convincing." (p. 8) The problems are those that this medium shares with computer assisted instruction and, indeed, with any technology that attempts to replace the personal interaction of student and teacher with a non-human device. We will have more to say about these problems below.

University of West Florida.

The University of West Florida has been working since 1981 to develop a 160-hour training program for newly hired employees of the Florida Health and Rehabilitative Services. The program consists of nine video disk sides, 78 floppy disks, and eight reference manuals. Development costs approached $1 million not counting start-up and learning expenses.

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A pilot test of the materials was done in 1983 with 13 candidates. They were positive about the training, which reduced instruction time 25% over classroom training. Trainees consistently scored 15-25 points higher on the final examination than did classroom trainees.(22)

Discussion.

This example is a further illustration of a point made many times in this report, that the studies of the new technologies are too limited as yet to provide a basis for decisions regarding their effectiveness and utility.

Another very critical point suggested by this example has to do with development time and costs, and the time that will be required to bring the development to a cost-effective level. According to the report, the program has been in development for some three years and cost nearly $1 million. The question has to be raised as to how stable the training requirements were over the development period, and, even more, how stable they will be during the time the program must remain viable if the program is ever to become cost-effective. The report notes that 500 employees will be trained in 1984. That puts the cost for development only at $2000 per trainee. To bring that cost down say to $200 per trainee would take, at that rate, ten years of training. In today's world it is unlikely that any training program can (or should) continue to meet needs for that length of time.

Of course, if the reductions in instructional times and improvements in learning remain consistent as the program is implemented, the development costs may be more than recovered in a much shorter period of time. The critical question is how valuable to the organization are the time saved and the increased levels of learning.

C. COMPUTERS.

In education computers can be the subjects of instruction, as in courses on "computer literacy" or programming; they can be used as tools for accomplishing tasks in which there may be a great deal of learning occuring, as in their use as word processors in writing courses or as design tools in many areas using graphics; they can be used to deliver instruction either prior to application (Computer Assisted Instruction — CAI) or at the time and place of application (Embedded Training); and they can be used to manage instruction (Computer Managed Instruction -- CMI). It is only as deliverers and managers of instruction and that computers will be considered here.

1. Computer Assisted Instruction.

In Chapter XII we will give a brief history of programmed and individualized instruction, two efforts to develop a technology of instruction that preceded the development of computer-based instructional technologies. One of the first persons to attempt systematically to develop the instructional uses of computers was Donald Bitzer at the University of Illinois. In 1960 he began the development of what was to become the PLATO system. Large grants from the National Science Foundation, the Office of Naval Research, the Defense Advanced Research Projects Agency, the National Institute of Education and private foundations provided funding for the developmental phases. According to Marc Tucker, director of the Project on Information Technology and Education, about one billion dollars have been invested in the development of PLATO since its inception.(23)

In 1963 Control Data Corporation (CDC) began a cooperative venture with the University and in 1967 it assumed full responsibility for the marketing of the system. CDC and the University have just announced a "third generation" partnership agreement for on-going research and development of PLATO. (24)

The full PLATO system runs on a time-shared basis from a large CDC mainframe which can support over 1000 terminals. The PLATO terminal contains a touch-sensitive display panel and keyboard, and can control various multi-media devices. Communication is via a CDC network or networks of the user organizations. Some of the PLATO software has been reprogrammed to run on CDC's own and other microcomputers, but because of the more limited capabilities of the micros, some features of the full PLATO system have had to be sacrificed, including most of the management functions. The software includes an authoring language, over 8000 hours of courseware and a management system.

Because of its long history and because it is one of the most widely used CAI system for adult learners, we use it here as the illustrative example of CAI.

In the area of adult basic education, PLATO is being used in settings such as in a downtown, urban, community center in Charleston, S.C. run by the National Center for Work and Learning in Washington, DC, and a local community college. It uses PLATO to provide basic skills courses in remedial reading, mathematics and language arts for youth and adults, 58% of whom are employed full- or part-time. Preparation lessons for the high school equivalency examination (GED) are also available. (See Chapter VI for a description of another program run by Central Piedmont Community College in Charlotte, NC.)

In Washington, D.C. PLATO is used for GED preparation in the federally-funded Educational Opportunity Center located in the Anacostia section. In Baltimore, ABE courses and GED preparation lessons are used by older adults at the Baxter Senior Center, where PLATO computer terminals are available. Many of the older people are also seeking jobs and find that receipt of the GED is a job-hiring prerequisite. Complete data on adult participants in these ABE projects is not available.

Another use of CAI as demonstrated by PLATO is as a tool for broad career planning and exploration. Adults facing career changes or job displacement can use PLATO's career-guidance courses to learn how to evaluate personal and professional needs and capabilities, how to research the job market and how to plan long- and short-term goals. These CAI materials can be used wherever PLATO is available — in colleges and universities, in business and industry settings, or in CDC-sponsored Learning Centers located in nearly 100 cities across the U.S. where, for a fee, anyone can use the PLATO materials. CDC does not have participant data for these PLATO courses.

Since 1978 CDC has used PLATO as the major component of "Fair Break," a program developed to attack the causes of chronic unemployment. The computer is used for remediation in basic skills, for high school equivalency instruction, and for development of "life management skills." There is also a training course for program staff called "The Helping Relationship."

CDC claims that Fair Break is "at work in more than 50 agencies nationwide" but gives evaluation data from only three programs. They show high school equivalency completion rates of 92.6% and positive program terminations at 76.3%. (See Chapter VI for further discussion of the uses of PLATO in remedial education.)(25)

PLATO as a CAI system also permits a variety of vocational training applications where broad job- related skills can be learned by persons seeking employment in specific fields as well as those workers already employed. Companies use PLATO to provide vocational training. For example, Motorola, Inc. started a pilot program in 1982 using PLATO at its Franklin Park, IL. plant. The CAI system is used to teach employees basic and advanced electronics.

Individuals who wish to start their own businesses can use PLATO in CDC Learning Centers, where more than 100 courses created for small enterprises in such areas as how to establish and manage a small business, accounting and selling, purchasing, and government regulation are available.

The military services have used and evaluated PLATO in a number of locations. Jesse Orlansky and Joseph String of the Institute for Defense Analyses in Arlington, VA, have done a comprehensive analysis of the military use of PLATO and other computer-based instructional training systems in the most thorough treatment of training technology of any that we have encountered. We shall discuss their assessment of PLATO and other systems in Chapter V.(26)

The Army, through the Army Research Institute and a contract with Florida State University, is developing the use of PLATO and other CAI systems with authoring capabilities to train Army personnel in basic skills and learning strategies deemed necessary to perform tasks required for Army job grades E1 through E5's. Florida State is midway through this large curriculum development project at present. A CAI system such as PLATO was utilized, according to Army personnel, because the resulting curriculum will provide uniform instruction to a wide variety of military personnel scattered across many sites. Previously the Army had relied on individual instructors and, as would be expected, the quality of the resulting instruction varied with the capabilities of the individual teacher. The use of CAI permits standardized instruction levels unable to be achieved with individual instructors, the Army believes.

Actual and specific job training is also provided using CAI systems like PLATO. For example, 112 GM plants are using PLATO to help retrain workers to maintain new types of automated equipment. The on-the- job training includes basic electronics as well as diagnostic and trouble-shooting techniques. CAI systems can then be used in dislocation prevention programs and help workers to develop new skills for new jobs and new equipment. In many cases, instructional designers work closely with production people so that when the new equipment is introduced, the instructional material is ready. General Electric is setting up training stations using PLATO on the shop floor — a close merger of CAI-supported training and work.

In these examples of PLATO as a CAI system, the computer is not the sole device utilized. PLATO relies on mixed media, including text, videotape, video disk, audiotape and other tools depending on the requirements of the particular course. There is often an instructor or aide at the site to help with problems, provide encouragement, or just be available to provide a human presence. Rarely does one find use of a CAI system for education and training of adults that relies solely on computer use.

In industry and the military, the two components of PLATO that are reported to be used even more than the library of courseware are the instructional management system (see next section) and the authoring language. The authoring capabilities

differentiate PLATO from many other CAI systems, permitting local sites to develop their own courseware. The TUTOR authoring language "contains over 250 commands which fall into five large groups: display, calculation, branching, answer judging, and data collecting". It includes "templates" - a subset of the authoring commands, which, it is claimed, enable subject matter specialists with no training in instructional design to develop usable, individualized instructional programs. These templates are being using increasingly to produce customized materials to meet specific and, often, rapidly changing training needs.

In later sections, we will discuss the advantages and disadvantages of PLATO and the computer generally as in instructional tool and the information available regarding effectiveness and cost effectiveness.

2. Computer Managed Instruction (CMI)

The individualization of instruction puts a heavy record keeping load on the instructor. Keeping track of each student's progress through the differing possible paths in an instructional program and being sure that the right lesson and material is assigned at the right time is a formidable task. The computer's huge and rapid data management capabilities have helped solve this problem through computer-managed instructional systems.

Because of computational and data storage requirements, most CMI systems have in the past been designed to operate on minicomputers or mainframes. However, with the growing capacity of microcomputers, CMI systems are being designed to run on them as well. The computer that contains the management system, is often networked to microcomputers through which instruction is provided and from which information is obtained for monitoring purposes. Instructional programs provided on "stand alone" computers usually do produce records of student progress.

It is not, however, necessary for students to receive instruction from the computer in order to have CMI. All that is necessary is that there be some way to input information about student learning activities. When the student is receiving instruction on the computer the results of that activity can be entered automatically into the student's record. When the student works away from the computer, test results or other information about student progress have to be entered into the computer in some way.

Each time information is entered, the student's record is updated and available for retrieval. That retrieval may be by students, instructors, course designers, and program administrators. The nature of the information that may be

obtained and the simplicity or complexity of reporting formats are determined by the system designer. These may range from simple reports on the class grades on the latest examination to retailed reports on each student's progress on each of hundreds of learning objectives, including comparison of each student with the class as a whole, all the student's in a program and nationally established standards.

In well-designed CMI systems instructors, course designers and program administrators can not only get information organized in any way that is useful to them, but they can manipulate the information to get answers to questions that will help them improved course design or delivery and program management.

CMI helps students keep track of their own progress. If they are using the system to receive instruction, each time they sign on the system starts them at the point they left off the last time. Through diagnostic tests, the system can determine what the student knows and need not study and what s/he does not know and needs to learn. Thus learning time is conserved and students avoid the boredom of repeating lessons already mastered.

Whether or not they are receiving instruction via the computer, students can get information about their performance that is helpful in their own self-diagnosis. This is one of the powerful ways in which the computer helps put control of learning in the hands of the learner, a factor that is particularly important for many adult learners.

This ability to monitor instruction was cited as one of the strongest reasons for choosing Control Data Corporation's PLATO system by the University of South Florida, Ohio State and the Centers for Disease Control, and by the Niagra-Orleans Board of Cooperative Education Services in up-state New York for choosing the basic skills system from Computer Curriculum Corporation (CCC). Both of those systems have an instructional as well as a CMI component.

Another approach to CMI is the Camelot system developed by Miami-Dade Community College. Only a management system, it provides a highly flexible framework that allows any instructor to design a management system for his/her own course. The feedback from the system can include detailed analyses of the student's performance as well as prescriptions for further study to correct weaknesses or progress to the next set of learning objectives. This system has recently been reprogrammed to run on several widely available microcomputer systems which, of course, lowers its costs and increases the numbers of institutions that can make use of it.(27)

Examples of CMI systems in use by the military are:

Army: Automated Instructional Management System (AIMS) Field Artillery School, Fort Sill, OK.

Navy: Computer Managed Instructional System, Naval Air Technical Training Center, Millington, TN.

Air Force: Advanced Instructional System (AIS), Air Force Technical Training Center, Denver, CO.(28)

These systems can handle large numbers of students: for example, AIS can support up to 3,000 students a day in four courses. In this arrangement the instruction does not occur at the terminal. The student's test answer sheets are read into the computer from an optical reader and the student receives a printout which tells him how well he performed, what lesson to do next, and where to find it.

One of the great advantages of CMI is that it reduces the record keeping burden for instructors. All of the data is automatically entered into the system and can be retreived on demand in many different ways. Where CMI does place a greater burden on instructors is in making meaningful use of all of the data that is available. Without proper training in the use of the data, instructors can become so overwhelmed with the volume of data that they either give up on using it entirely, or spend excess time trying to make sense out of it.

Like all of the other technological tools discussed in this report, CMI is no panacea. To be an effective tool, its use must be carefully thought through and it must be integrated into a total instructional system.

3. Embedded Training.

The newest application of computers to instruction is in the form of what has come to be called "embedded training." Embedding means the incorporation of training within the work process. Instead of learning prior to and at a different site from work, embedding makes training available when needed at the place and usually on the machine where it is to be applied.

We first encountered the term "embedded training" in our interview with Joe Harless, one of the leading consultants in the field, and thereafter encountered it or accounts of the phenomena so many times that we became convinced that it is an important trend in the nature of training.

The movement toward embedded training is being driven by a number of forces in contemporary technology which would seem to insure that this practice will become widespread in a wide

variety of work settings. Chief among these forces are the increasing capacity of microchips, their incorporation in more and more machines, the speed with which new machines are introduced and their high reliability of most chip-based devices.

As the microchip with its increasingly large memory capacity is incorporated into more and more devices, it becomes cost-effective to embed instructions in the device itself on how to use it. Most devices that use microchips now include diagnostic circuitry that speedily identifies any malfunction in the equipment.

At the same time, equipment life is getting shorter. At Western Union International, according to Bruce Ingraham, Director of Training, equipment used to last twenty years or more. The "life expectancy" of the training to use and repair such equipment was therefore long enough to justify high initial investment in training. Today equipment remains in use five years or less. It has become too costly to train workers in the traditional way every time a new machine is introduced. Even with the cost of producing the embedded training, it is being found less costly to do the training that way rather than ahead of need.

WUI has, therefore, gone to embedded diagnostics and training, thereby reducing both the pre-service training time and the time at the work site to do the job. "Look and swap" is the way that Ingraham characterized the practice of reading the diagnostics, taking out the defective component and inserting a new one. The defective part might be thrown away if it was more costly to repair than to acquire, or sent to a repair facility if it was repairable.

A further extension of this approach, reported by NCR and AT&T, is the use of remote diagnostics and repair. This is possible when the operational system is in software and devices are connected to communications systems.

Because of the increasingly high reliability of most solid state, high tech devices, they can go for long periods without any operator intervention. Also, most machines now have such large numbers of functions that many of them are only used infrequently. (Think of the functions built into newer word processors in comparison with those available in earlier models.)

When tasks are performed only infrequently workers often forget much of what they are expected to know in order to perform the task. Rather than provide frequent refresher training which still may "decay" before use, it has been found more effective to make the necessary information, including modeling of the necessary behavior, available on a "when needed" basis at the point of use through embedding.

Where once word-processors computers and computer software were accompanied by large and, often, incomprehensible user manuals, increasingly the user guidance is being "embedded" in the devices or on the disk in the form of job aids that are available when one needs to know how to perform a particular function. This same approach is being applied throughout the world of "high-tech" in CAD/CAM machines, in communications switches, in military hardware, and now even in consumer products.

In the continuum of devices used for embedded training, the one closest to "reality" is when the device used on the job is also used in training. In effect, the tool itself also becomes the training device. Much of computer training is now of this nature. One of the most interesting applications of this approach is the word processing training program developed by Manpower Services.

Five years ago Manpower faced the problem that is now becoming endemic throughout the entire economy: how to train employees on new technologies as they come along and do so in a cost effective manner. They saw that with changes in office equipment they could no longer expect to send a person with typing skills into an office and have her able to go right to work. They needed to train temporaries to be able to handle Wangs, Xeroxs, IBMs or whatever might be encountered. Moreover, since their employees tend to stay with them for only short periods, they could not afford to invest a large amount in their training.

The company went through an extensive search to find a training system that was fast, effective and cost effective, one that would work with large numbers of people in dispersed locations. They first tried the training programs and manuals supplied by the equipment manufacturers, but found them to be written in a language and at a level of complexity that was inaccessible to their people. They examined many packaged training programs, but found that all of them tried to teach far more than they felt was necessary in order to begin to use a machine.

One of the key difficulties was that none of the programs was written from the operator's point of view in language that was ordinarily used by secretaries. Because of their difficulty all of these programs tended to increase the fears of the learners, which were great enough anyway.

The company then undertook a systematic analysis of the training problem to see if they could devise a solution that would meet their requirement. Here in summary is how the analysis went, according to Manpower President, Mitchell Fromstein.

A. PROBLEM: Language of the manuals was too difficult and not related to that of the users.
SOLUTION: Rewrite manuals in "secretarial language".

B. PROBLEM: Most of trainees had been out of school for a long time and were not accustomed to long training sessions.
SOLUTION: Make short training modules, put them into the machine that is the subject of the training and personalize them. This was done by producing the revised manuals on a disk for the machine that was to be learned. Each segment is short enough to appear on a single screen and focuses on a specific function of the machine that the operator "needs to know" in order to operate it. (They got rid of all of the "nice to know" or "what to do if" stuff that fills so much of most manuals.)

C. PROBLEM: Many trainees are fearful of the new machines and their impersonality.
SOLUTION: Using the global search and replace feature of the machine, they put the student's name at appropriate points throughout the lessons, thus making the learner feel that the training was really addressed to her.

D. PROBLEM: Many trainees have doubts about their ability to master a complex new machine. The resulting stress inhibits learning and reenforces their feelings or inadequacy.
SOLUTION: The training is given in a tutorial setting with a trained supervisor present to get the trainee started. The trainee is shown how to insert the disk, turn on the machine and call up the first screen. At the point the program takes over and begins by showing the student how to move around in the training program.

Both the supervisor and the program tell the student that there is nothing they can possibly do that will hurt either the machine or the program. Since the procedures being learned to move around in the training program are regular word processing functions, the student begins learning the machine from the very first key stroke. The discovery that they can control the machine almost immediately lowers the stress level and increases learning rate.

E. PROBLEM: How to know if the trainee has mastered the program to a sufficient level.
SOLUTION: At the end of training disk, the trainee is asked to compose a letter to the president of Manpower about the training program. Successful completion of an acceptable letter is viewed as a valid performance test. Fromstein has over 14,000 such letters, many with suggestions for improving the program. Since the disks are themselves "documents" produced by word processor, it was easy to make corrections and improvements, making the version in the field always the latest one.

In addition, Manpower has a paper and pencil screening test to determine if persons seeking employment have the skills they claim and at what level. The trainees are given that test at the end of the training and must meet the same standard as any person who is hired by the company.

F. PROBLEM: Because trainees often do not get assignments that allow them to use their new skills, account has to be taken of the decay of learning if skills are not applied immediately or regularly.

SOLUTION: They allow the trainees to return at any time and go through disk again. Usually less than an hour is sufficient as a refresher. They have also created an "operator support manual" which is a small, purse-size version of the material on the training disks. It is carefully indexed by the kinds of terms and functions the user would want to reference, with "screens" reproduced exactly from the training disks. Furthermore, there are even color coded instructions so that the function can be performed "by the numbers".

The result of this effort, Manpower claims, is that a person who has never used a word processor can learn enough to go into an office and function effectively in 8-15 hours of training. Most do this in one day, some take up to a full second day. After working for about two weeks on a first system, a person may come for advanced training on the first machine or for training on a second system. To learn a second system takes usually less than half a day because the focus of the initial training is on functions, which do not vary much from system to system.

Manpower invested $6 million in the development of the training program. It hopes eventually that the cost per trainee will work out to $30, which makes this very competitive with word processing training programs available elsewhere. Moreover, Manpower charges customers 20-25% more for a word processor operator than a typist, so that increased profits will also be generated by the investment. In addition, Manpower has adapted the system to teach software such as Multimate, Lotus, and Visicalc and is adapting it to do training for networked environments.

Other software producers are also moving to embed training in their packages. William H. Gates, one of the leading software developers and now CEO of Microsoft Corp., Bellevue, WA, recently said: "Over time we expect to include CAI with every one of our applications packages. That is something the entire software industry is pushing towards because it is so crucial."(29)

In contrast to Manpower, Kelly Services, another temporary services provider, has developed a word processor simulator which allows training for differing word processing machines all to be done on one machine. JAM, a training company in Rochester, NY, has an intermediate approach: it has a video disk training program that works in tandem with a Wang Word Processor.

No one has done a nice comparative study of these three approaches and it is doubtful that a truly valid study could be devised. In each case, the test of whether the approach selected is effective will be in the performance of the trainees when they are out on the job. Each company monitors on-the-job performance and know very quickly when problems with its training approach arise.

As to the cost-effectiveness of the approaches, that is highly dependent on a great many variables, as we will show below when we discuss this topic.

The movement toward embedded training has profound implications for many aspects of employment and training:

1. Far less training needs to take place prior to employment or prior to assignment to a specific task. This may reduce the cost of training.

2. With embedding it becomes possible to shift certain key operations from employees to customers. One of the most visible manifestations of this development is the Automated Teller Machine. The next step in this evolution is going to be to move the teller function into the home. Indeed, as the "technology of embedding" improves, the skill requirements on the part of the end-user decrease to the point where vendors are now shifting the responsibility for installation and maintenance to the user. "Plug and Play" is the slogan at NCR, according to John Morohl, Director of Technical Training, which means that even complex machines are now delivered to the users without the necessity of having field staff come out to install them.

3. Because embedded training is best done while the device or process is being designed, increasingly instructional designers are being brought in as part of the product or service planning and development team. This collaboration between machine designers and trainers is one of the strong trends that has emerged in our research.

D. SIMULATORS.

Simulators are devices which duplicate the behavior of real-life machines (like ships or airplanes) or complex systems (like subways and power plants). Orlansky and String have done a

study of simulators in the military very similar to the study referred to above on computers.(30)

Simulators differ notably in their resemblance to actual equipment, their functional capabilities as instructional devices and in their complexity and cost. They are either two- or three-dimensional. The 2-D devices display the simulated device or system on a panel. The student responds to the situations presented, which are selected by the instructor or the program. Simulators perform as if they were real equipment because each contains a computer with a mathematical model of the real system.

Simulators are attractive as training tools for a number of reasons:

1. They enable a trainee to accumulate "hands-on" experience without the danger and expense of damage to an actual machine or system.

2. They accelerate the rate of learning since many training occasions can be provided in much shorter time than in the real situation. As Judith Robinson, marketing manager for Digital Technology Center says,

> Simulators in many cases provide the only solution to training problems that are too costly or dangerous to create in an actual process situation. Without simulators trainees cannot be prepared for such things as equipment failure because firms cannot afford to let equipment fail and then let a process run its course.(31)

3. They can provide a larger variety of malfunctions than would be possible to have occur easily on operational equipment or systems.

4. They are generally less costly to produce than actual equipment.

5. Records of student performance can be maintained automatically, thus giving instructors more information about performance than possible on actual equipment.

6. Students appear to take less time to learn on simulators.

7. Another role for simulators is in "on-demand" training situations. In increasing areas of technology the time between failures is getting so long that maintenance personal go for long periods without ever seeing particular events. Rather than giving them training that they will probably have forgotten when they need it, designers are providing when needed maintenance training. When a failure occurs, the technician goes through a simulation of the problem to be solved.

Simulators are programmed to respond to student input in as close approximation as possible to the way the real device would. Link Pilot Training Simulators are one of the best known such devices. Other examples of the applications of simulators are in the training of:

a. Merchant seamen in docking and navigating supertankers. Sophisticated simulators reproduce the conditions of the major world waterways including detailed graphic presentations.
b. Operators of nuclear and other energy plants.
c. Technicians in the operation of communication satellites.
d. Space shuttle crews.
e. Process operators in chemical plants and refineries.
f. Military maintenance personnel.(32)

Until recently it was very costly to produce simulators that would function for anything but the simplest situations. However, with the advent of microchips and video disk, the cost of simulators has come down. Moreover, manufacturers have developed software packages that can be used for a number of different simulations. With their greater availability, the understanding of how to design and use them goes up, so that they are likely to become increasingly important in training.

We have also been told that in various situations the line between simulation and reality is getting hard to draw. The trainee starts out doing simulated exercises and gradually the exercises become "real", as for example, when in CAD/CAM the device on which the student is learning by simulating designs is hooked up to the production machine and an actual product is produced from the design.

E. EMULATORS.

Emulators, or what Orlansky and String call three-dimensional simulators, are the next step closer to reality from simulators. Emulators look and perform very much like the actual equipment except that they are made rugged to withstand student abuse and with special safety features to prevent exposing students to dangers. They may not contain all of the components of the actual equipment and may operate more slowly or, for example, with lower resolution and less memory. The advantages of the emulator are similar to those of the simulator except that the experience of working with them is more realistic.

At the Milwaukee Area Technical College, Victor Langer uses them to teach CAD/CAM. The students are exposed to exactly the same problems they would encounter on the job and, except for the speed of response, they get the same results as though they were working on the real machine.

The field of computer graphics and animation is also now using low-cost emulators to prepare people for use of more powerful graphics design machines. These machines are introducing powerful new communication tools for all areas of training. Ours is a highly visually oriented society. The most powerful impact that television has had on education has not been as a result of its use in formal schooling, but has come from the thousand of hours of television watching that our children do even before they start school and during all their years of school. Many people learn more through graphics communication than through aural or print and some people — those whom we have labeled as "learning disabled" — may only be able to learn through visual imagery.

Up to now, producing visual images was costly and, relative to what is now possible, cumbersome. Today graphics systems can be purchased for under $5000 that have the capability that only a few months ago would have cost $50-100,000. And artists with the new machines are discovering expressing capabilities that were never possible before.

Examples from two extremes of the learning continuum are suggestive of what is becoming possible. In medicine a considerable portion of what a physician in training had to learn was how to "translate" the blips on a screen into an understanding of what was going on in the organism generating those blips. Today, with new imaging systems, the student can see arteries expand and contract under differing stimuli. These are not merely simulations of the "real" thing, but computer transformations of the data into pictures instead of blips or tables of numbers. The result is that the student — or the experienced physician learning a new procedure — can achieve understanding of processes and interactions much more directly than was ever possible before.

At the other extreme, Guy Nouri, president of Interactive Picture Systems in New York, has developed a frog dissection program for elementary school children. It permits even very young children who lack the motor skills to do a dissection to identify the parts of a frog on a computer screen and to do various "experiments" to discover how those parts function together.

Similar programs can be developed for every complex system and it is certain that creative designers will develop visual means to help people grasp even very abstract concepts. One of the most important areas for application of this technology will be in the area of basic skills. Adults — and children — who have been barred by their difficulties with print and abstract reasoning from acquiring the skills needed to solve problems and function effectively in a complex society may be helped by our ability to express ideas in visual imagery.

F. TELECOMMUNICATIONS.

Television is the most widely known and used form of telecommunications for instructional purposes but it is by no means the only nor, probably, the most important long run use. As we noted in the discussion of television above, one of the limitations of broadcast and most cable television is that it is one-way communication. To be most effective in education and training communication must be at least two-way — between teacher and student — and, preferably, "multi-way" to include communication among the students. In adult education particularly the opportunity for learners to express their thoughts to others and get feedback from them is an important part of the learning process.(33)

Increasingly now the telecommunications that is being used for education and training is more than one-way. The three primary forms are audio, video and computer.

Audio teleconferencing involves the use of the telephone to connect participants in two or more locations. Because almost everyone uses a telephone regularly and may even have participated in a conference call, it is often thought that audio is simple. However, as Bullen and Johansen point out, "audio systems are the most technically difficult of any even video."(34)

This is because people will accept fuzzy pictures on video, but if they cannot hear clearly communication fails. To achieve high quality audio requires sound-treated rooms, sensitive microphones, preferably voice actuated so only the speaker's microphone is "live" at any one time, good connecting switches or "bridges" and clear lines. Such facilities are now available from several commercial vendors and in at least one state system of education, Kansas.

The Kansas Board of Regents has for many years operated a statewide audio conferencing system over which courses are offered to students, primarily part-time adults, throughout the State. The courses run the full gamut of offerings including, heavily, courses for continuing education in the various professions. Students may participate either at conferencing centers located throughout the State or from their own phones.

The primary advantage of the system is that it enables people to takes courses who would not otherwise be able to do so or only if the University went to the considerable expense of sending instructors to off-campus locations. Studies of the program over the years have indicated that students in the tele-courses do as well as on-campus students.

A business application of audio conferencing is the use of a system called Teleforum for professional development and management training in office automation. The sessions were held five times during the year and each of the thirty participating organizations had between five and twenty-five people present. At an average of ten people per session, the cost was less that $20.00 per training hour, which, according to N. Dean Meyer represented "a dramatic price breakthrough for high-level professional development."(35)

The drawback to audio conferencing in addition to the facility/equipment problem, is that most people find it hard to participate actively in such settings because the usual visual cues are not present to indicate who is to speak next and the speakers have no way of telling if anyone is paying attention. It is not, therefore, a medium that is likely to be used widely for worker education and training. Also, of course, such training usually requires some visual material and, often, the need for demonstrations or hands-on experiences which are not possible in a pure audio system.

Both video and audio conferencing require that all participants be on-line simultaneously, a factor that limits their utility in instructional situations where it is difficult to arrange for instructors and students to be be at their several locations regularly at the times instruction is scheduled. This difficulty is eliminated by the third and newest form of teleconferencing, computer conferencing.

This medium results from the linkage of computers and telecommunications systems. A single computer, which may be anything from a micro to a mainframe, serves as "host". To participate in a computer conferencing system, one needs only a computer, terminal or word-processor with communications capability, a modem — a device to connect the computer to the telephone system, and an account on a conferencing system. From most places in the U.S. a local phone call will connect one with the system. Once connected, one can read and send messages. The messages are stored by the host computer and delivered to the intended recipients whenever they sign-on and ask to see their messages. This feature means that people communicating with one another need not be on the system simultaneously. Moreover, messages may be sent not only to one or more individuals, but they may also be sent to "topics" or "conferences". It is this last feature that is the basis for the instructional use of this medium.

In a course offered via computer conferencing, the instructor may enter lectures as "messages" and/or make assignments in books or materials distributed by mail. (When the mails are used, computer courses become a powerful new tool for

correspondence education.) Students may "attend" the lectures at any time from any place where they have access to the necessary equipment. Increasingly, that place is likely to be their own homes. The students may leave their own messages. These may be questions for the instructor or comments on his presentation or on comments made by other students. Because of the ease with which students can react to others in the course, there is often as much interchange among the students as there is between the students and the instructors.

Because the messages are stored in the computer, students can enter courses at any time and, if they have to miss portions for any reason, everything is there waiting for them whenever they sign in. Since access can be had from anywhere, students who travel can, with portable computers, keep fully up with the rest of the class.

At any time that a subject comes up that is of interest to only some members of the class, they may set up a "branch" conference for discussion of that topic — with or without the participation of the instructor. Instructors, too, can use the branching feature to structure the course.

Participants may also send private messages to one another or to sub-groups within the larger group. Instructors can use this facility to provide individual guidance to class members who may be having difficulties with particular aspects of the course content or with the conferencing process.

If students are required to prepare written work of any kind, it can be delivered "on-line," and the instructor can return comments in the same way. Course work may also require accessing on-line data bases and the results of that effort can be shared either with the whole class or just with the instructor.

Using a polling facility that is available in most conferencing systems, instructors can use feedback devices of all kinds from short quizzes to reactionnaires to elicit opinions on issues raised in the course. These latter often provide rich material for further discussion since, after "voting," participants can see the results of the voting, although not how any individual voted.

Computer conferencing has been used for several years by the Western Behavioral Sciences Institute for high-level management seminars. The advantage in this application, besides eliminating the need to have participants take time away from their jobs, is that they can relate what they are learning in the seminar directly to their jobs. Many of the "exercises" involve discussions of real problems in "real" time.

The New Jersey Institute of Technology has been giving a number of its continuing education courses, such as ones in management, computing and communications via its computer conferencing system called EIES (Electronic Information Exchange System). This fall the New York Institute of Technology will be offering degree credit courses over its conferencing system called "Participate" which was developed by Participation Systems, Inc.

Another variation on the use of computer communications for instruction is the concept being developed by TeleLearning Systems Inc. in San Francisco. One of the limitations on the extensive use of computer conferencing of the kind described above is the cost of time for communications. Telelearning has addressed that problem by providing a communications package which automatically connects the student to the system and sends and receives messages very quickly. All the student's writing and reading is done off-line.

TeleLearning is aiming its offerings at adults who wish to complete their education or up-grade their skills in specialized areas. Its current catalogue includes non-credit personal improvement courses, some degree-credit courses, and courses to help prepare people for the College Level Examination Program (CLEP) from the College Board. Each instructional package includes textbooks, study guides, computer disks with lessons and exercises, and the communications package. Students respond to the assignments by writing their responses on a disk and then signaling the system to send them. Instructors generally respond within 48 hours so that the student gets a rapid response to his "homework". There are also opportunities to engage in discussion with instructors.

According to Telelearning staff member Laura Malone, it is hoped that this rapid response time and opportunity for some interaction will mean that the attrition from TeleLearning courses will be significantly less than from traditional correspondence courses.

TeleLearning courses now run on Commodore, Apple and IBM computers. The communications package runs from $49-$199 depending on machine, and the course fees range from $45 for some non-credit courses to $250 for some three-credit offerings.

David Hughes, a private teleconferencing consultant in Colorado Springs, has been conducting his own writing courses on his own conferencing system which he operates on a microcomputer in his home. His examole shows the potential for private entrepreneurs to by-pass institutional structures to offer learning opportunities to those who want them. Of course, situations of this kind raise large issues of control and

"consumer protection" just as do the offerings of the institutions mentioned above, since their courses can be "delivered" in any state regardless of whether or not that state's educational authority has approved them. But each new technology challenges existing arrangements and, in time, accommodations between the new and the old are usually made.

Just how valuable a tool for adult education and training computer conferencing becomes will depend in part on the spread of computers with communications capability and in part on the quality of the offerings provided. For some adult learners, particularly those who are severely handicapped or have jobs that make it impossible to meet any regularly scheduled classes, it will be the only way that they can participate in organized learning opportunities.

G. JOB AIDS.

Embedded training, which was discussed above, is a special case of a more generic approach to helping workers perform effectively on the job. That approach is called a "job aid." A job aid is a procedure for helping a person remember or learn how to do a task at the time when that task is to be performed. It is, according to Donald Bullock, "anything that is added to performance to enhance or improve it."(36)

Bullock distinguishes aids from prior instruction in terms of the extent to which performance depends upon guidance provided by the aid and upon recall from prior instruction. He says:

> Job performance aids reduce the need for reliance on recalled skills/knowledge, even though instruction in the use of job performance aids may be (and usually is) necessary.

Such aids, he claims, are more cost-effective than instruction, more timely in that they can be developed faster than an instructional program, more easily updated than instruction, and more relevant to a specific job. They also can help smooth the transition from instruction to job performance.

That is exactly how job aids are used in the blood analyser training system developed by DuPont Biomedical Products, according to Thomas Jenkins, Manager of Learning Systems. A self-instructional learning system was developed to replace the lecture-style training program that had previously been used to train operators from around the world in the use of this complex piece of equipment.

Formerly trainees listened to lectures, saw demonstrations and had limited opportunities to practice on the

actual equipment. The new training involves the use of text, audio and video tapes, CAI and instruction embedded in the equipment. The system cost $900,000 to develop but because it cut training time from five days to three and permitted the training to be done with half the amount of staff on twice as many machines for half the cost of the previous training, the investment was paid off in 18 months.

As important as were all of those savings, back home job performance improved. Jenkins attributed this to the fact that the students learned to use the machines on their own (with the help, of course, of what might well be called "instructional job aids") and had access to most of those aids when using the machines. This was a case where the job aid did what Bullock suggested: smoothed the transition from instruction to job performance.

Many of the most effective job aids do not require the use of technological devices at all. Well-designed print or graphic materials are often all that is required. These may not differ much from old-fashioned maintenance manuals except in the attention that is given to their design. Indeed, many of the trainers whom we interviewed argued that the determination of when and how to use job aids is itself a "technology" and should be noted in any overview of how technology is helping with the training task.

The Little Company of Mary Hospital in Evergreen, IL, with its more than 1800 employees serving some 18,000 patients in a year at a total budget of $72 million, is a typical metropolitan area hospital. According to Gregory Finnegan, education director at the hospital, they make extensive use of job aids in many of departments. For example, job aids are used to reduce the training required for maintenance personnel. Every valve, switch or other device that might cause trouble has a job aid attached to it which describes what is to be done in case of trouble. This procedure made it unnecessary to have a skilled building engineer on-site at all times and enabled the regular maintenance crew to handle most problems — indeed handle them <u>before</u> they became emergencies.

Among the departments using job aids and the problems addressed by them were these:

* Blood bank blood warmer operating guide: Nurses did not operate equipment often enough to become proficient.

* Laboratory sweat test procedure guide: Off shifts with fewer chances to do the procedure need reminder.

* Nursing arterial flush procedure guide: Staff needs to learn to use new equipment.

* Nursing bristoject procedure guide: Staff needs to know procedures to conform to new regulations.

* Plant operations air conditioner procedure guide: Infrequent use creates a training problem.

* Plant operations water in furl tank troubleshooting manual: Occurs rarely and is emergency.

* Radiology ultrasound procedure guide: Made possible operation by others than chief technician.

These were some of the results of using the aids:

* Medical services cart washer procedure guide: Before took two hours to train staff to use: with aid 30 minutes.

* Medical services washer/sterilizer procedure guide: Before 8 hours to train: with aid 30 minutes.

* Blood bank blood warmer guide: Before Blood Bank received two calls per week to show nurses how to operate: with aid, no calls.

* Intensive care unit arterial flush guide: Before supervision required for 30 minutes per use 10 times a week: after aid no supervision required.(37)

Many trainers with whom we talked said that an increasingly frequent response to a situation that might in the past have led to a training event is development of a job aid. Job aids seem to be prescribed whenever the skill or knowledge required is so infrequently used that, even if people were trained, much of what they are required to do has been forgotten when the time came to use it.

They are also used on jobs that require workers to remember lots of detailed steps and do them in proper sequence. Such jobs put a heavy burden on the memories of the workers. In order to insure that procedures will be followed, in the past it has been necessary to provide sufficient opportunity to practice the procedures to be sure they would be performed with minimal error. With job aids, the memory burden can be reduced. In the case of telephone service representatives, training time was cut by one-third and errors were reduced through the use of job aids.

H. OFF-THE-SHELF PROGRAMS.

Over one hundred vendors advertise programs using almost all of the above media, singly or in combination, for a wide range of training needs. Only very rarely did any

interviewee mention the use of such packages, except for users of the PLATO, CCC and WICAT materials. Morohl did say that NCR used a McGraw-Hill course in basic electronics that involved self-paced workbooks, with some audio and video tapes.

We did hear assertions that were few or no good programs (Bullen, Katz, Gustifson, Buffer, Harmon, Harless, Hoelzl) and assertions that good training has to be situation-specific and cannot be met with off-the shelf programs no matter how good. We have no way of judging these claims and found no evidence of any systematic evaluation of the claims for effectiveness of the packages, except for the journal, HRD Review, which is published specifically to provide trainers with evaluations of training materials. In the year and a half since it began publishing, the Review has evaluated more than 125 training programs, of which nine were classified "multi-media" and twelve were "video-based." While reviewers, who are volunteers from the training field, are encouraged to try the materials in actual work situations, there is no way to assure that this is done or to impose any sort of common criteria on the reviewers. The reviews are limited to 500 words.(38)

According to George Khoury, editor and publisher of the Review, the response of trainers to the publication has been very strong. "They welcome guidance from an independent source," he says, "to help them sort out the claims of the vendors." His impression from talking to subscribers and vendors is that the use of packaged training programs is growing. Videotape is the most widely used of the media, with very little yet appearing for computers.

We did search to see if there were any off-the-shelf programs for adult basic skills other than the PLATO and CCC materials. There is a television series designed to prepared adults to take the GED examination. Although developed many years ago by the Appalachian Regional Laboratory, it is still used by some adult education programs over cable systems. Users say that it does help adults who stay with the program but there have been no recent assessments of it.

The closest to a computer-based program that we could find in this category is the GED-100 Program developed over the past two years by Educational Software and Marketing Co. (ESM) of Springfield, IL. That program, however, does not provide instruction but only uses a microcomputer for diagnosis, testing and prescription. When students' deficiencies are identified they are referred to class and texts for remediation.

According to ESM president, William Mayes, no systematic studies of the effectiveness of the program have been done. In two years it has only been bought, at a cost of $975, by 40

institutions. It has, however, just been acquired by a publisher of adult basic education materials, Steck-Vaughn. Mayes said that he has been on the look-out for instructional programs that would complement the GED-100 but has found nothing.

One other packaged program that involves considerable use of media is the Adkins Life Skills (ALS) program developed by Winthrop Adkins at Teachers College in New York City. This program has been extensively used with displaced workers. ALS focuses on the problems individuals face when they are out of work and need to find a job. It is claimed that it works both with new entrants to the labor market, such as youths and displaced homemakers, and with previously employed people who may never before have had to look for a job.

The core of the program is a set of video tapes that present in dramatic form the kinds of problems that people encounter in the the process of seeking a job. The tapes are designed to stimulate discussion in small groups with a trained leader who helps the participants work out solutions to the problems that they have and that the tapes help them to articulate and externalize.

Adkins chose video tape as the medium for instruction because he had become convinced as a result of years of work as a trainer of adult counselors that there was no way that enough properly trained people could be prepared to meet the needs of all the adults who need some form of counseling assistance. "I felt strongly, however," he said, "that people could only be helped deal with situations in which they were really hurting in interaction with other people." He therefore decided to use technology to capture the expertise of the trained counselor in a form that could be used by less trained individuals. "What we produced," Adkins claims, "is a set of tapes that skillfully help people identify the sources of their problems and a set of print materials that help facilitators and learners in a group setting work through to solutions."

While ALS has been used by over 300 programs and there are strong claims for its effectiveness by those who use it, there has been no systematic study to determine how well it works in comparison with other methods.

Because the numbers and costs of off-the-shelf programs involving the use of technology is certain to increase, an important study would be to examine the basis for the claims of the vendors and to conduct an independent evaluation of the more promising programs. Such a study should assess not only the individual offerings, but seek to identify the characteristics of programs and the uses of media that are effective with differing kinds of learners in differing situations and learning settings. The HRD Review has made a start in this direction, but a more extensive effort is need than can be mounted by volunteer reviewers for a publication with limited resources.

III. FUTURE HARDWARE/SOFTWARE SYSTEMS.

There are many hardware and software developments which are or are expected to be available in the near future that will greatly effect the education and training of adult workers. Almost all of these use hardware, software and concepts that already exist but are not yet used for instructional purposes.

Joseph Lipson of WICAT Systems has provided the following list of future educational technology in the workplace that is feasible in the next decade with current or projected hardware and software capabilities:(1)

* Truly portable learning stations with a flat, high resolution screen that could be used at the worksite to support "embedded training which has the potential to revolutionize learning in the workplace."

* Low-cost, high speed, letter quality, small laser printers. Would facilitate workplace learning by providing letter quality hardcopy printout at the worksite.

* Low-cost, easily usable optical character readers which would permit any text document to be read into computer memory without having to be re-typed. Would greatly increase access to information resources for training purposes, particularly in rapidly developing fields like engineering and computer science.

* Condensed and synthesized speech to accompany still frames on video disk. Would increase the information content of the instructional program since it often takes more words to explain a picture than can be put on the present disk sound track.

* Speech recognition. Would have broad application in training from reducing the time and effort needed to learn to operate complex machines or software systems, to enabling anyone to generate text without having to use a keyboard. In combination with graphics systems, would enable anyone, but particularly non-literates, to develop and express ideas.

* Computer written programs. Would reduce the training needed to write programs and increase the availability of computer-based training programs tailored to specific situations or learner needs.

* An authoring technology (equipment and theory of authoring) for interactive video disk production. Would greatly increase the efficiency of course development.

To this list Verl Dennis, of Arthur Andersen Co., adds wider use of voice synthesis. When anything appearing in words on a screen can be sounded out, non-literates will be able to use computer-based devices and any trainee will be able receive instructions without having to take eyes away from work.

The Department of Defense already has a device that uses the spoken word for communication with the user. Called "Personal Electronic Aids for Maintenance (PEAMS):

> It offers immediate access to technical information for experienced and inexperienced users. The inexperienced technician can follow the step-by-step procedures....Its objective is to solve, through automation, the problems that have prevented wider use of job/skill performance aids.... Because the information is delivered and reviewed via spoken word, the PEAMS system avoids some training and job performance problems related to low literacy levels.

PEAMS may also have the kind of "authoring technology" that Lipson is looking for since it:

> offers a complete production environment, including a fully integrated, high-performance work station for the production of text and graphics: structured authoring tools such as front-end analysis, troubleshooting procedure development, nomenclature control and procedural text development without use of a keyboard: graphic development tools tailored to the technical illustrator: and project management tools such as schedule/task control, personnel management, configuration management and on-line communications. The author can incorporate relevant technical instructions, background policy information and systems specs into one easily adapted and updated delivery system.(2)

While PEAMS combines video disk and computer, some project that instructional technology will only become effective when computers can handle text, data, graphics, still and motion pictures, and sound all in digital form and can use the telecommunications system to share that information among computers. The technology to achieve that degree of integration is presumably very close to becoming commercially available.

Louis Robinson of IBM supports Lipson's view that simpler user interfaces with computers are coming:

> Machines must become much less complicated to use. I believe that is happening....Knowledge based systems or expert systems are interactive and are built around data structures which can represent all the relevant problem domain facts and their interrelationships. Its interactive dialogue acts as an

> intelligent consultative system to the user....Information processing has certain inherent complexities... Until now, a great portion of that complexity was handled by the user. But (soon it will be) absorbed by the computing system itself.(5)

One variation of the expert system approach was under development by the military called "Intelligent Computer-Assisted Instruction" (ICAI). According to Orlansky and String:

> In ICAI subject matter knowledge is stored in the computer, but not in the form of previously defined lessons. Instead, the computer models each student and selects stored subject matter material to construct instructional interactions for individual students. These interactions can be very flexible, and hold some promise for "human like" tutoring of students.(4)

"Expert systems" are likely to have two significant impacts on training:

1. They will, on the one hand, reduce the type and amount of training required for knowledge-based occupations such as the professions.

2. They will, on the other hand, make it possible to embed in machines the growing understanding of how to motivate and assist people to learn. In Christopher Evan's dramatic language:

> The computers and the programs they offer will be carefully prepared to make sure that the user, at whatever intellectual or cultural level, will be highly motivated to use them....The world is about to move on from the era where knowledge comes locked up in devices known as books....In the era it is about to enter, the books will come down from their shelves, unlock and release their contents, and cajole, even beseech, their owners to make use of them.(5)

An adult education future much less dominated by technological devices was projected by a group of educators convened by the National Home Study Council in 1981 to examine the future of distance education. After reviewing dozens of futures projections, this group of 25 made a number of predictions which included the following:

*Printed correspondence course text materials will be the key component of the distance education package of 2001. (A striking contrast with the views of Evans, Lipson, and many others who see technological delivery predominating by that time.)

* Home study educators will "rediscover" the media of radio and telephone conference calls as means for direct interaction with students.

* Adult students will want to interact with advisors, counselors or instructors on a "real time" basis.

*Communications will be the vital link between the student and the instructor.(6)

To be sure, distance education is only a part of adult education and training, and the Home Study Council may have a special interest in having the results come out as they did, but, given the history of the spread of innovations in education, this group may turn out to be closer to the mark than some of those expecting more revolutionary changes. We will discuss the barriers to rapid adoption of innovations in education in Chapter XI.

IV. SETTINGS IN WHICH TRAINING OCCURS.

Our investigation by no means constitutes a systematic attempt to identify the numbers of organizations that are using technology in the education and training of adult workers. Our impression is that they now must number in the hundreds, including most community colleges and public and private vocational-technical schools, and such giants as the U.S Department of Defense, General Motors, IBM and AT&T.

One of the unions whose members are most involved with technology in their day-to-day work is the Communications Workers of America (CWA). It has a major program for continuing workplace education. According to Glen Watts, president of CWA, "a key ingredient of this program will be the CWA's support of community colleges and vocational technical schools in their development of courses, some of which are directly related to the development of information industry skills."(1)

The comments of Dale Parnell on the respective roles of business, industry and the colleges is of special note because of his special perspective as president of the American Association of Community and Junior Colleges (AACJC). In a recent Association newsletter he wrote:

> The conundrum of the century is the degree to which schools, colleges, and universities are buying technical training programs from business and industry....Have business and industry taken over the training market? Where do community, technical, and junior colleges come down in all of this?...It will be most difficult for our colleges to keep up with the specific requirements of companies operating at the cutting edge of new technologies. However, as a given technology develops, the required competencies become transferable among many different employers. It is at this point we see the training function increasingly being transferred to our colleges. This transfer process requires the formation of new partnerships and a continuing dialogue between colleges and employers.(2)

We found a number of institutions in which that transfer is already taking place. The institutions are working closely with individual industries or consortia to design curricula and put in place opportunities for the kinds of hands-on training that is essential in most high-tech fields. Indeed, a characteristic of each of the examples that follow is that the technology used to deliver instruction is in most cases also the technology that is the object of instruction, e.g., students use computers to learn about computers. Is such use of technology only an up-dated version of traditional vocational training in

which hands-on experience played a key role, or is the technology also playing a role in the delivery of the instruction? The impression that we have gained is that in most instances training designs are embedded in the devices so that the student's use of the tools is being in part guided by the tool.

An example is what has happened at the Milwaukee Area Technical College (MATC) which faced the problem of providing high-cost high-tech CAD/CAM education for industries in the area. At the core of the problem was the high cost of industrial CAD/CAM stations which at $150,000 per design station was more than the College could afford. With help from the industries involved in the form of donated equipment and funds and a grant from the National Science Foundation, MATC "implemented a high-cost industrial CAD/CAM technology training system achieving a ratio of 35 students to one design station available 80 hours a week." These coupled with low-cost microcomputer CAD emulators and a curriculum developed in close collaboration with an industry advisory committee, has made it possible for the College to help address the need of industry for "some 100,000 operators in the four years ahead."(3)

Another example of an institution that closely integrates its instructional delivery system with the technology in which it specializes is Capitol Tech in Laurel, MD. The students learn on the technological devices that they are learning about such as computers and state-of-the-art telecommunications equipment.

Another partnership between business and industry has been formed by the Telecommunications Training Consortium with headquarters at Skyline College in San Bruno, CA. The basic purpose of the consortium is to create a nationwide educational program for the telecommunications industry based primarily in the "nation's community colleges." One objective is "to offer all instruction in a computer-assisted, video-interactive format that is easily transported."(4)

Another institution that has entered actively into the dialogue with an industry with which it is closely associated is the Fashion Institute of Technology in New York City (FIT) which recently celebrated its 40th anniversary. In a publication setting forth its mission for the future, Marvin Feldman, FIT president, succinctly positioned his institution this way:

> The line of demarcation between the fashion industry and The Fashion Institute of Technology is invisible. FIT is a central part of the fashion industry as well as a center of learning <u>for</u> the industry.(5)

Elaborating further on this theme in an address to the New York Board of Trade, Feldman said:

> If technology is blurring the traditional distinctions in manufacturing and distribution, it is practically eradicating the distinction between industry and the educational institutions that train its people. There is no more dramatic phenomenon in the 1980's that the explosion of the collaborative efforts between industry and education as they try to cope with the torrent of change the electronic revolution has produced.(6)

That revolution, according to Feldman, is the only thing that will save the textile industry from near extinction in this country. With the help of new computer-based machines, it is "becoming almost worthwhile to produce textiles again in this country." The reason is that the textile and fashion industry, like to many others, is being transformed by computer-based processes and machines that will soon displace most of the crafts if not the craftsmen in the traditional garment trades.

For example, today a designer draws a design on paper which is then turned into patterns by a pattern maker; those patterns are laid out on cloth and cut by skilled fabric cutters — three separate skills all requiring long training and manual dexterity. In the new system, the designer will do his/her work at a computer graphics terminal which will allow for greatly enhanced opportunities to experiment with alternative designs. When the designer is satisfied with a design, the machine will translate the design into directions for a cutting machine. That machine will not only lay out the patterns on the cloth so as to minimize waste to a degree that only the most exceptional older worker could attain; it will also cut hundreds of pieces of cloth simultaneously to tolerances unattainable by even the most skilled craftsman.

Thus old skills will be replaced by new and many fewer workers will be needed to do the new jobs, although, Feldman suggested, new jobs will be created in other sectors of the industry such as marketing and direct customer services. Just as important, new levels of creativity and of quality control will also be possible.

All of these changes are just coming into place. One of the roles the Institute is playing is to help introduce these changes to the industry. It conducts regular seminars for industry and union leaders on the new systems and machines and it is training the workers who will introduce and use the new systems and machines.

Here Feldman pointed out a dilemma that institutions like his face in trying to provide the training for advanced technologies. The industry is still dominated by large numbers of small firms that are using older technologies. Since they are

the primary sources of jobs for graduates of FIT, students have to be trained in the traditional technologies. But to enable them to help change the industry, they have to be trained in the new technologies as well. To do both jobs at the same time is expensive.

The problem is compounded by the enrollment-based funding formulas used by most public authorities. Those formulas do not recognize the high per student costs engendered both by the need for redundant training and by the high costs of the new technologies.

In spite of these limitations, FIT is making heavy use of technology-based instruction to prepare students for the "new" textile industry. Much of that instruction is done using the technology itself, as when student designers are taught design on computer graphics machines — a practice similar to that which we found in other industries using high technology.

Cuyahoga Community College (CCC) in Cleveland, Ohio, is another example of a two-year institution using a wide variety of new technology devices to educate students, most of whom are adults (average student body age is 29). CCC uses the PLATO system for instruction. In addition, CCC produces its own telecourses which are sent to eight cable companies in the Cleveland area via WVIZ-TV's ITFS system.

The school is now able to offer advanced courses to its three separate campuses through a new two-way microwave link. The system is designed for two-way audio and video transmission, so that the instructor can view students at distant locations through special monitors as well as hear them through microphones.

From 1972 to 1976 PLATO was evaluated at five community colleges in the Chicago area. One hundred sixty two classes in accounting, biology, chemistry, English, and mathematics were evaluated. Average student use of PLATO varied from a few minutes to more than 20 hours. The most significant finding was that student achievement with PLATO was about the same as for regular classroom instruction. Because of the way PLATO was used to supplement classroom instruction, comparisons of time to achieve objectives was not relevant. (For further discussion of this study, see Chapter V.) (7)

A similar program, TICCIT (Time-shared, Interactive, Computer-Controlled, Information Television) was evaluated in 1975-76 at Phoenix College, Arizona, and the Alexandria campus of the Northern Virginia Community College. Over 2600 students were enrolled in the TICCIT courses and they were compared with about 3000 in corresponding lecture courses. The TICCIT students had

slightly higher test scores and completed the courses at a higher rate than the lecture students. However, other data indicated that the TICCIT students were more highly qualified than the other students, which could account for most of the differences. (See Chapter V for further discussion.)(8)

It is unlikely that many of the students involved in those programs were adults so that even if the results were more meaningful, we could still not be sure that they would apply to the populations of interest here. We were not able to follow-up to see if these systems are still in use and whether adults are now involved.

A 1983 comprehensive study of telecommunication in educational institutions by Raymond Lewis included 14 two-year colleges which were using a variety of devices to serve their students, many of whom, being off-campus, were adults.(9)

Two of the institutions had programs especially for workers — the College of San Mateo and Rio Salado Community College. San Mateo operates an Electronics Worksite Training Project funded by the California Worksite Employment and Training Act. The project provides entry-level training (not using technologies) and up-grade training for workers already in entry-level or other limited-mobility jobs in the electronics industry. The project also enrolls 170 students in a program it operates in 22 learning stations located in 12 different companies in the San Francisco area. It is one of the few microcomputer/videotape interface instructional programs in the United States, offering employees a self-paced, open-entry/open-exit curriculum at a worksite.(10)

Rio Salado , a noncampus college of the Maricopa County Community College District, uses television, radio, cassettes and other devices to reach its 1,000 students, 67% of whom are employed and 73% are women. Programs at the school also serve students at a women's prison.

The majority of the courses are in credit bearing introductory core and elective liberal arts subjects. In addition, some courses in occupational subjects and in areas of interest to adults in the community, such as in small business management and nutrition, are offered, but not for credit. The occupational courses are part of a program called Occupational Update for employed people, not for persons seeking to qualify for employment.(11)

Lewis' findings regarding the other two-year institutions are summarized in Table II.

Except for the use of television, four-year colleges and universities seem to be less involved in the use of technology

48.a

Table II. To follow page 48.

Table II.
INSTRUCTIONAL TECHNOLOGY AT TWO-YEAR COLLEGES.

COLLEGES	Broadcast TV	ITFS	Microwave—point to point	Cable TV—one way	Cable TV—interactive	Slow Scan TV	Video Teleconferencing	Radio	Telephone	Audio Teleconferencing	Telephone Access Audiotape	Videotape	Audiotape	CAI	CMI	Computer—videotape	Computer—cable
Central Piedmont CC	•			•				•	•		•	•	•				
Chicago City-wide CC	•							•	•			•	•				
Coastline CC	•							•	•			•	•		•		
College of San Mateo									•			•		•		•	
Columbus Tech. Inst.					•				•			•					•
Dallas Cnty C.C. Dist.	•			•				•	•			•	•				
Kirkwood CC		•	•	•			•	•	•			•	•				
Los Angeles CC Dist.	•								•			•					
Miami-Dade CC	•	•		•				•	•			•	•		•		
Milwaukee Area Tech.	•			•				•	•			•	•				
Northern Virginia CC	•							•	•			•	•				
Queensborough CC									•	•				•			
Rio Salado CC	•			•		•		•	•	•		•	•		•		
Tacoma CC				•				•	•		•	•	•				

Source: Raymond J. Lewis, Meeting Learners' Needs Through Telecommunications: A Directory and Guide to Programs (Washington, DC: American Association for Higher Education, 1983).

for the training of adults (or youth, for that matter). Writing less that two years ago, Fred Davison, president of the University of Georgia, observed that "recent breakthroughs in semiconductor technology are beginning to provide educational institutions with technology at the price and the capabilities needed for major changes." And commenting on his own institution he said, "In the past, the University has not engaged extensively in computer-based instruction. This year (1982), however, an aggressive new program will lead to the installation of up to 100 CBI stations."(12)

The reason that Davison (and others) believe that not much is going on in the colleges and universities may be more the of writing about developments than because such developments are not occuring. As Marc Tucker writes in his collection of descriptions of computer activities on campuses:

> Campus leaders most directly involved are much too busy...to write reflective articles for scholarly journals describing the fast moving events in which they are key participants.(13)

Tucker then describes four applications of computers to instruction:

* At the University of Maryland, where computer simulations on Atari 800's are being used to teach beginning optics.

* At Colorado State University, where a course in macroeconomics will be taught using an off-the-shelf software spreadsheet program, Visicalc, running on Commodore computers.

* At the University of Illinois, where an approach called "hypertext" is being used to change the way pathology is being taught. (Hypertext is another future system that we might have discussed earlier.)

* At Milwaukee Area Technical College. (See discussion above.

Tucker concludes his survey by noting that:

> Computers and telecommunications systems are on their way to radically transforming the way work gets done in our society, and they (the universities) are prepared to make commensurately radical changes to be sure that...they will have...an approach to teaching that enables both student and teacher to make the most of the time they have together.(14)

However, in an even more recent commentary on computers in higher education, Alfred Lee from the New Jersey Institute of Technology writes:

> With some exceptions, higher education has waited to see whether personal computing is really more than an infatuation with an obedient tube. Although it helps with office work, why should it belong in the general curriculum? To much of the national professoriate, computing is still something the computer science department does." (15)

As a result of the current FIPSE-funded survey by the Educational Technologies Database Project at Harvard, we will soon know much more about "the uses of microcomputers in educational settings nationwide." A questionnaire was sent this summer to schools, higher education institutions and "alternative educational settings." Since the instrument addressed to this latter group is the only one which explicitly asks if the programs serve adults, it is provided here to show the kinds of information being sought.

In light of our discussion below on the limited information available on effectiveness, it is interesting to note that the survey only asks for effectiveness information in a very indirect way and is hardly likely to turn up any useful data on effectiveness unless some "piece of software or software package" turns up in a large number of the responses, a result, we would predict, that is very unlikely given the varying objectives and standards of judgement at differing institutions.

Information about projects using technology in the instruction of adults is also available in the catalog of computer projects published by the Department of Education. The catalog lists all projects funded by any DOE agency in 1983.(16)

Of the 275 projects listed, 45 or 16% involved adults. These 45 programs accounted for $4.8 million or 6% of the total of $77 million of the awards. In view of what has been said elsewhere in this report about the high cost of developing effective computer-based instructional programs, the most significant feature of the summary is the range in size of the awards from one under $2,000 for one year to one over $800,000 for three years. Almost half (19) of the projects were under $25,000 per year and all but 10 were under $100,000. Even with the local contributions that were probably necessary in almost all cases, these are not, for the most part, at the scale that would produce results that are likely to be usable elsewhere. Nevertheless, most of the abstracts mention some form of usable product and dissemination activity — even those where the funding is less than $5,000.

Of the 14 projects categorized in the catalog as "Research and Evaluation," only one grant, to the Shenandoah, PA, school district, provided for a comparison of adults receiving traditional instruction and those receiving CAI. That grant was

To follow page 50.

Harvard University Educational Technologies Database Project

MICROCOMPUTERS IN ALTERNATIVE EDUCATIONAL SETTINGS

PART A: Uses of microcomputers:

1. Are microcomputers in your facility used primarily _____for instruction, _____for resource, _____for informal access? And is the instruction carried out primarily by _____staff, _____certified teachers, _____volunteers, _____peer teachers, or _____self?

2. What is the age range of your participants? (Check all that apply)
   Preschool_____Elementary school_____Secondary school_____
   College_____Graduate school_____Adult_____

3. What brands and how many microcomputers do you use?
   AppleII,IIE_____ Atari_____ Commodore_____ DEC_____ IBM_____
   MAC_____ Radio Shack_____ Other(please list)_____

4. Approximately how much time does each participant spend using a computer per week?

5. What types of software are participants using in your program? (Check all that apply)
   ___Word processing___Database systems___Spreadsheets___Communications
   ___Software for specific subject areas(e.g., math, history, economics,etc.)
   ___Graphics___Programming languages(specify)_____

6. Is there any particular piece of software or software package that you have found to be especially effective? Have you developed software for this use yourself? Please name and describe briefly.

7. What other materials are used?

8. What are the main objectives you hope to achieve through the use of computers in your course or program? What makes your use of technology particularly interesting or successful?

9. Please include a brief written description of how microcomputers are used in your facility. Include here information about use in labs, workshops, networking of micros, or networking of micros to larger systems as well as information about the substance and variety of materials available. If you need more space attach another page, but please do not write more than 200 words.

for only $11,500. For that amount, no findings of any broad significance could have resulted.

Three others were concerned with software evaluation and the rest are concerned with developing guidelines or information resources for educators who want to use computers for instruction of adults.

The Department of Education, of course, is not the only Federal agency that sponsors education and training programs that involve adults. In 1976, we identified over 270 Federal programs providing education and training funding and programs for adults, dispersed across 11 different departments and numerous agencies and commissions.(17) The number of current programs is surely reduced, due to substantial budget cutbacks and, of course, only a portion of these would use the new technologies as part of their efforts.

In addition, to the Departments of Education and Defense, the Agriculture Department uses computers and other new technologies to train adults through the Extension Service. Health and Human Services sponsors the Centers for Disease Control which uses various training technologies in its programs. The Department of Labor is currently sponsoring research on the educational and employment implications of technological change in the auto industry (including robots). These are just a few examples of the scope of Federal activity.

While we did not study this specifically, our impression is that, beyond Orlansky's military studies, little evaluative research has been done on Federally-supported efforts in this area.

Earlier in this section we discussed the role of universities as users of technology in their own instruction. Another of their roles is to prepare people to design and use technology in instruction. Many people with whom we spoke in industry were concerned at their failure in this role.

For example, Verl Dennis from Arthur Andersen & Company, said that they had sixty people doing training this past summer but only five of them had the ability to use the kind of training technology they require. "The universities," he said, "are not turning out people with this kind of skill."

It is often said that one of the reasons for the slow adoption of educational technologies in our educational system is that so few of our teachers or faculty have learned anything themselves using technology. This is just beginning to change and it may be that the next generation of teachers will be more attuned by their own learning experiences to the role that technology can play.

Of even greater concern from the perspective of engaging universities in collaborative arrangements with industry, many spoke of the strong barriers within institutions to the kind of interdepartmental collaboration that would be required to create a strong program in instructional design.

Although we made no attempt to identify institutions with significant programs in educational technology and have no way to judge those we did hear about, we did receive descriptions of rather comprehensive sounding programs from the following:

Florida State University in Tallahassee — doctoral programs in "instructional design and development" and "instructional theory and practice."

San Diego State University — Certificate and master's degree programs in "educational technology" with a speciality in "educational computing."

University of Delaware in Newark — master's program in "computer based education."

Each of these programs makes a point in their literature of stressing that their programs prepare people for careers in industry. Allison Rossett, Professor of Educational Technology at San Diego State, states that the emphasis there is on examining performance problems on the job and then creating instructional packages to solve the problems. "We attempt," he writes, "to pair design and hard technology (computers, video, interactive video) courses." As illustrative of the link with industry, the University is "currently offering a Certificate in Training System Design and Administration for AT&T course developers in New Jersey."(18)

V. EFFECTIVENESS STUDIES.

We found very few systematic studies comparing educational technologies with traditional instruction or with other technologies for instructing adults. One of the few studies we did find begins with an explanation of this situation:

> Evaluation has come late to the field of adult education. Because many programs for adults are of short duration and the curriculum is often non-sequential, evaluation attempts frequently have consisted of participant assessment rather than measurements of learning change. In addition, most of the technical competence necessary for evaluation is housed in educational institutions oriented almost exclusively to elementary, secondary and college education.(1)

Andrew Molnar at the National Science Foundation is one of the best informed observers of learning research in the nation. He told us that "there is no evidence from research that media make a difference in learning."

Richard Clark of the University of Southern California agreed with Molnar and has argued publicly that no further comparative studies of the influence of media on learning be undertaken because:

> Most current summaries and meta-analyses of media comparison studies clearly suggest that media do not influence learning under any conditions....Basically, the choice of vehicle might influence the cost or extent of distributing instruction, but only the content of the vehicle can influence achievement.(2)

Over and over when we asked interviewees if they had done systematic studies of the programs in which they were using technology for training, the answer was negative. The reason may be indicated by a recent comment on evaluating training programs:

> When training produces immediate improvements in performance every time, and those increases are large enough to be seen despite the inherent variability of behavior in the natural environment, then these designs provide powerful and convincing demonstrations of training effects....Unreliable programs are not bottom-line contributors.(3)

In short, businesses look for obvious measures of difference, such as significant savings in learning time, in travel costs, or in improvements in on-the-job performance. If the effects are large enough to be easily perceived, controlled studies are not needed to find out if the results were valid or

reliable. It works or it doesn't seems to be the prevailing attitude. And, of course, businesses have found many devices that work, as we shall show shortly.

Even in educational institutions, where it might be thought that there would be more interest in research, the studies have been meagre, for the reasons given by the Shwalbs. Research on adult learners generally has not had high priority, and this includes research on the use of differing technologies for teaching adults. There has been such a backlog of research on adults that in a 1978 research agenda for adult education, an advisory panel convened by Kurland did not include any topics related to technology in its list of 30 priority issues.(4)

The most extensive studies have been done by the military, but even there the efforts have been limited, as we will show later in this chapter.

A look at the forty studies found by the Shwalbs illustrates the points we have made.

They looked for studies "comparing the effects of technology instruction with adults and conventional instruction." From data bases for the period 1960-1980 they culled only forty usable studies, providing 43 comparisons of interest to them. Before we look at the studies, it is important to take note of a comment from Mrs. Shwalb on one of the key criteria used in selecting studies:

> We included as an "adult" any person who did not follow the typical sequencing of education, i.e., adults in ABE programs, military personnel, etc., and those in higher educational training programs, i.e., medical students and other graduate training. Hindsight suggests that this second group should be looked at separately from a-typical adult learners. (Correspondence.)

Were this second group omitted from the studies looked at, probably at least eleven would be dropped, leaving only twenty-nine in a twenty year period. Table III has been constructed from the information provided by the Shwalbs.

In the following discussion, the first number always will be based on the full set of studies, the second with the eleven omitted.

First there is the matter of the technologies studied. The largest category was programmed instruction (27/24) (See Chapter XII for discussion of programmed instruction); "visually based instruction" was next (13/7) (only three of these were identified as involving television (2) or videotape (1)); and only four (two) were concerned with computers. This distribution is not surprising for the period covered.

Table III.

SUMMARY OF FINDINGS FROM COMPARISON STUDIES OF MEDIA WITH ADULT LEARNERS

Media/ Study	Date	Doc. Type	Number of Subjects Exp./Cont.		Type of Learners	Findings
Programmed Instruction						
Bushnell	1963	E	23	31	Journeyman Electrician	+
Carson	1971	D	25	63	ABE Reformatory Inmates	0
Coleman	1964	C	52	52	Aircraft Mechanics	+
Cougle*	1972	D	19	19	Managers	+
Delfin &	1979	J	16	17	Crisis Workers	+
Goldberg&	1964	J	33	14		0
Hafn & Holder	1962	J	14	19		+
Hampton	1967	J	328	164		+
Harris	1964	C	302	283	Air Force Personnel	+
Hathaway &	1964	C	?	?	Air Force Personnel	+
Hedberg &	1965	J	67	112		-
Hosmer & Nolan	1962	B	269	151		0
LaGaipa	1968	J	155	155		+
Hughes &	1961	J	70	42	Industry	0

Legend: Study -- See references.
* = Studies primarily involving graduate students
Type (of document) D=Dissertation; B=Book; J=Journal article; C=Conference paper; E=ERIC document.
Findings: + = Technology group significantly outperformed control.
- = Control significantly outperformed technology.
0 = No significant difference.

Based on information and tables supplied by Barbara Shwalb.

Table III. Page 2

Hull &	1965	E	30	14	Farm adults	0
Larue &	1964	C	55	15		0
Longo & Mayo	1965	E	200	200	Naval Aviation Personnel	0
Metcalf	1972	D	65	65	Functional Illit. Inmates	0
Meyer	1966	E	26	24	Air Force Personnel	+
Neale &	1968	J	269	185		+
Neidt &	1967	J	43	66	Industrial Employees	+
Olivas	1978	D	25	25	Bank Tellers	0
Orr	1968	J	89	89		+
Owen & *	1965	J	36	41	Medical Students	0
Wills & *	1965	J	34	17	Legal Students	+

Visually Based

Casko	1972	D	83	30	Orthoped. Appliance Makers	+
Chaney &	1967	J	7	6	Inspectors	+
Cline & *	1973	J	20	20	Psychiatrists	0
Eyestone *	1966	D	100	100	Researchers	0
Golden *	1976	D	20	20	Medical Students	+
Hatch	1968	D	8	9		0
Jones	1965	J	28	14	Industrial Executives	0
Monroe	1976	D	33	33	Parents	+
Randels & *	1976	J	80	82	Psychiatry Students	0
Ryan & *	1970	J	10	10	Psychiatry Students	0
Wright *	1979	D	18	15	Elementary Teachers	0

Table III. Page 3

						Computer Assisted
Deignan & *	1978	J	93	154	Medical Students	+
Diem &	1978	J	15	15	ABE Jail Inmates	0
Hirata	1973	D	70	214		0
Motley *	1972	D	16	16	Librarians	0

The attention to programmed instruction can probably also be accounted for by the fact that the procedure lends itself to evaluation. The use of measurable objectives is a key component of the method and it was initially fostered by researchers and psychologists who would have a special interest in promoting research on it.

James Kulik and the Shwalbs are now doing a study of research on CAI with adults and are omitting studies involving graduate students. It will be interesting to see what this investigation finds for the period since 1980. In an interview, Kulik reported that they had found ten good studies and that they seem on first analysis to show that CAI with adults does make a significant difference in outcomes.

A second factor to note about the studies is the limited duration of the courses studied. Twenty-three involved less than 10 hours of instruction and several of these would appear to have been only an hour or two. Only nine involved more than 20 hours of instruction. Thus these studies can hardly tell what would be the effects of regular instruction using technology for extended periods of time. However, as the Shwalbs note, "the longer the instructional period, the smaller the achievement effects for both traditional and technology-instructed adults." (p. 11) If this finding were borne out by more extended studies, it would reenforce the point made earlier, that media are not the significant factors in learning achievement.

The third factor to consider in evaluating these studies is the numbers of subjects. There were only about 2800 (2400 if graduate students are excluded) in the experimental groups in the 40 studies and somewhat fewer in the control groups. The largest group was the 328 experimental subjects in the Hampton study; the smallest was Claney and Teel with seven subjects. Only seven had more than 100 experimental subjects and more than half the studies, 22 in all, had under 50. Generally 50 subjects is considered minimum for a valid comparative study. These are, therefore, hardly numbers on which to base results in which much confidence can be placed.

With all these caveats regarding the data, we quote the conclusion reached by the Shwalbs:

> Technology was found to have a positive influence on achievement. The average adult in a technology-instructed class scored at the 67th percentile while the average adult in a traditionally-taught comparison class achieved at the 50th percentile. Specific factors related to effectiveness of technology for adults were: use of different instructors in the traditional and technology classes (i.e., when the same teacher taught both groups, differences in achievement

> were markedly reduced;) non-math classes; and instructional duration of less than 10 hours. The average effect size for achievement suggests that instructional technology may be more useful for adults than youth.(5)

While the Shwalbs base their conclusions on the results of the studies, those studies by themselves are insufficient to establish that any of the technologies make major differences in the learning achievement of adults. More confidence can be placed in the conclusions of users of technologies in business and the military because, as stated above, training technologies are seen as "bottom line contributors."

There is, of course, hope that the studies of CAI will produce more significant and positive results. However, the findings of James Kulik, the professor at the University of Michigan under whom the Shwalb's did their work, are not encouraging. In a similar meta-analysis of computer-based college teaching, Kulik and his colleagues identified 500 titles that met their criteria but ended up doing an analysis of only 59 reports that contained sufficient data.(6)

This study concluded that:

> Computer-based instruction made small but significant contributions to the course achievement of college students and also produced positive, but again small, effects on the attitudes of students toward instruction and toward the subject matter they were studying. Computer-assisted instruction also reduced substantially the amount of time needed for instruction.

The study made special note of the evaluations done on the two largest CAI programs, PLATO and TICCIT (Time-shared, Interactive, Computer-Controlled, Information Television, developed by the Mitre Corporation of Bedford, MA.) The evaluations were done with NSF funding by the Educational Testing Service. The results were summarized as follows:

> The evaluators of PLATO reported that both students and teachers reacted favorably to this computer-teaching system, but that PLATO had no significant impact on student achievement. The evaluators of TICCIT reported that this system resulted in an improvement in student achievement, but students in TICCIT classes were more likely to drop out than those in conventionally taught classes. The evaluators concluded that neither PLATO nor TICCIT had reached the potential so long claimed for computer-based instruction.(7)

An observation that the Kuliks and Cohen make about the two studies is revealing about the problems in doing studies of

instructional approaches that have any generalizability. They note that, although the study was large-scale and costly, "the conditions of the ETS evaluation limited the settings to which its findings could be generalized." (p. 527) They might have added that they were also limited as to types of learners and should not be generalized to adults, particularly adult workers studying in differing settings and with differing motivations than college students.

So far as we can determine, there are no current applications of TICCIT.

In an interview, Kulik indicated that he knows of no good studies of PLATO in industrial settings. Charles Marino, a vice president at Control Data Corporation which markets PLATO, agreed that industry is not interested in controlled studies. "The question asked is: Does PLATO deliver instruction equivalent to more conventional means at less cost? When managers look at the 'bottom line' the answer," he said, "is intuitively obvious." This confirms the point made earlier about the perspective of business on studies.

We now turn to an examination of the other major analysis of studies of the use of technology with adult learners, those done on military training programs by Jesse Orlansky and Joseph String of the Institute for Defense Analyses.(8)

They reviewed studies of PLATO and TICCIT done in a number of community colleges and reached the same conclusions as those summarized above. They did note that in both civilian and military applications the use of computers seems to reduce the amount of time required to achieve learning objectives, even when achievement results are the same. They make several pertinent observations about this result that are worth noting since it is sometimes argued that savings in time are indications of effectiveness.

"To the extent that student time is relevant to the analysis of cost-effectiveness, it is a measure of the cost and not of the effectiveness of training." One of the major reasons for this conclusion is the way in which CAI courses are designed for experimental purposes. The objective is usually to have the students attain the <u>same</u> levels of performance as students in the comparable conventional classes. Therefore, improvements in achievement are not likely to be detected.(9)

Also time has a very different value in military and business setting from that which it has in educational institutions. Because military personnel and workers are usually paid while in training, anything that reduces the time required to achieve a training objective results in a cost saving,

regardless of whether there are any other gains. The situation for schools is different. They seldom have any direct incentives to complete instruction faster. Some students may benefit from time savings if they are able to enter the labor force more quickly or complete training while still receiving income support. "A major consequence of these distinctions," Orlansky and String argue, "is that methods of instruction that are cost-effective for military (and business) training may not be cost-effective in other areas."(10)

It is very apparent from a review of studies of technology in training that the most exhaustive studies on training effectiveness have been done on military programs than anywhere in the civilian sector. The reasons are not hard to find: The military has a huge stake in improving effectiveness since it has a large training budget ($12.8 billion in 1983). Its maintenance budget is about $18-20 billion a year or 25% of its total budget. Improvements in training effectiveness in that one area can mean very large cost savings. The result is that the military has been willing to spend large sums both on ways to improve training and on trying to find out whether or not improvements really occur.

Given this situation it would be reasonable to expect that very definitive studies would have been done on training effectiveness, particularly in areas where the costs of training are high and the consequences of failure in effectiveness could mean loss of lives as well as dollars. Unfortunately, Orlansky did not find this to be the case. There are some important and useful studies, as we shall see, but Orlansky identified a major gap in all of the studies:

> The effectiveness of training should really be measured in terms of performance on the job, e.g., ability to diagnose malfunctions and to replace faulty parts, ... ability to operate tanks and radar, ... overall effectiveness in combat. However, this type of objective performance data is almost never collected.(11)

Only in the case of flight simulators is there evidence on the transfer of training to actual flight situations, i.e., pilots trained on simulators can actually fly planes.

A second problem with many of the studies is in the area of costs. Cost analyses are either not done, or cost data is too inadequate for valid comparisons. Orlansky says:

> It is easy to overlook the fact that resources are required to achieve any level of effectiveness, and that the amount of resources provided for training can readily influence the level of effectiveness that may be achieved.

> Thus, it is quite meaningless to consider the effectiveness of training without also considering, at the same time, the cost associated with that level of performance.(12)

Orlansky did assessments of three types of training devices: flight simulators, computers, and maintenance simulators. The overall finding was that:

> these methods of training are as effective as the more conventional methods to which they were compared (with the caveat that) effectiveness has been measured only at schools and not subsequently on the job. These methods of training cost less to acquire and use, but only limited cost data are available.(13)

In this section we will examine what Orlansky has to say about the effectiveness of various technology training devices and leave to a later section the more detailed examination of his cost-effectiveness findings. To anticipate the major conclusion, which justifies the separation of cost and effectiveness discussions, in 1979 Orlansky and String said:

> Direct comparisons of the cost and effectiveness of different methods of instruction are not now possible because only incomplete cost data were found.(14)

That statement was based on an analysis of 30 studies: when the following statement was made in 1983 they had found 40 studies and were able to qualify the above conclusion somewhat:

> Reduction in the time needed by students to complete their courses (about 30% on average), when translated into reduced costs for student pay and allowances, fewer instructors and support, can represent real cost savings due to the use of CAI or CMI. However, life-cycle costs (i.e., costs for the design, development and delivery of the training program throughout its useful life) for computer-based and conventional instruction must be considered before we know whether computer-based instruction actually produces overall savings in costs.(15)

The conclusion reached in 1979 on computer based instruction for the military was:

> Much of the data come from experiments of limited duration with relatively few students (note the similarity to the studies examined by the Stealths); by contrast, some CMI systems have been used four years. All findings are confounded by effects they may be due either to CAI or CMI, in comparison to conventional instruction, or to the revisions in course materials needed to modify a course from conventional to CAI or CMI instruction.

> CAI and CMI save about 30 percent (median) of the time required by students to complete the same courses given by conventional instruction...Student attrition appears to increase with CAI and CMI...but changes in student quality may also account for this increase.(16)

Two points should be noted: First, courses are almost always structured more systematically when they are adapted to CAI or CMI: were conventional courses similarly restructured, they too might produce improved results. This means that it is almost impossible to hold the course content constant while only changing the mode of delivery.

Second, in any large scale study it is almost impossible to hold student quality sufficiently constant to rule out changes in students as a factor in any differences of results. Even when students are matched statistically, changes not detected by the data may influence the outcome.

In 1983, after closer analysis of a larger number of studies, Orlansky found only eight (six CAI and two CMI) systems where achievement of students was compared with achievement in the same courses taught by conventional instruction. (See Table IV. Commenting on the data, he wrote:

> The table shows clearly that student achievement at school with CAI or CMI is about the same as, or in some cases superior to, that with conventional instruction. The amount of superior achievement is small.(17)

The results found for maintenance simulators were similar:

> Student achievement in 12 courses that used maintenance simulators was the same as or better than that in comparable courses that used actual equipment trainers: in one case, student achievement with a simulator was less.(18)

While the cost data tend to favor use of simulators, the overall conclusion reached is not encouraging for those who would like good studies on which to make decisions:

> The data on the cost and effectiveness of maintenance simulators have <u>not</u> been collected systematically. Therefore, there is <u>no</u> basis at present for making trade-offs between the effectiveness and cost of different types of maintenance simulator....There have been <u>insufficient</u> studies on the amount of student time saved with the use of maintenance simulators. There have been <u>no</u> studies on whether the use of maintenance simulators influences the amount of student attrition at school. There have been <u>no</u>

Table IV. To follow page 60.

Table IV.

FIGURE 10. Student Achievement at School: CAI and CMI Compared to Conventional Instruction

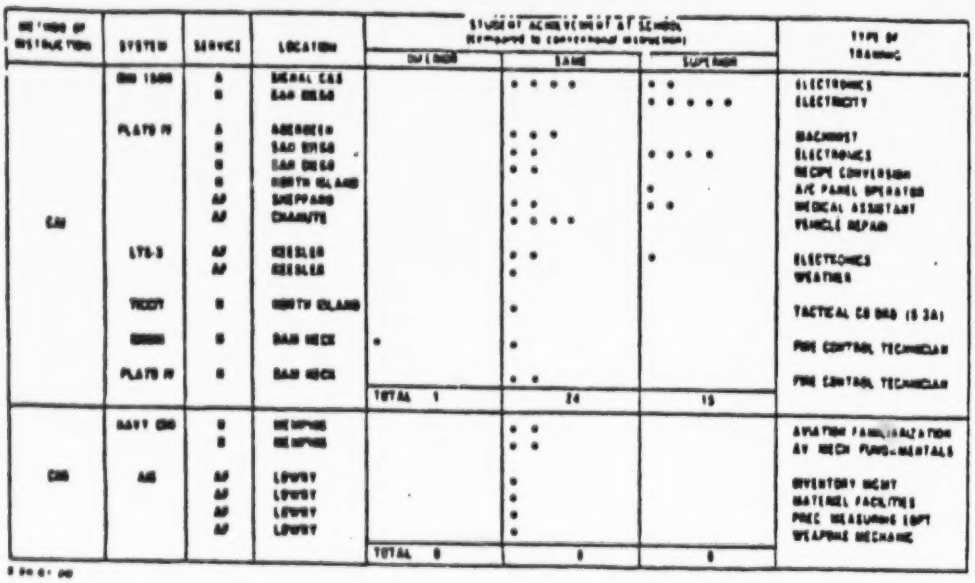
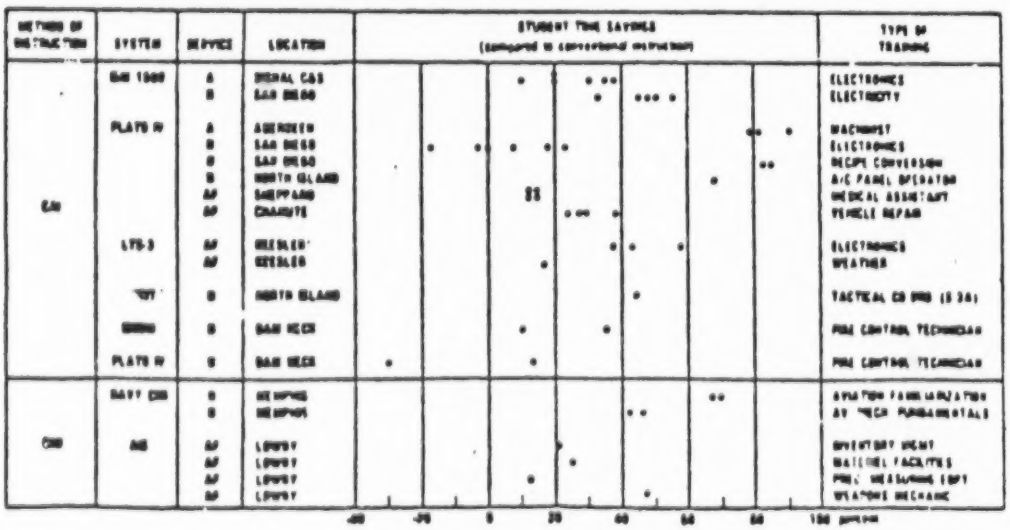


FIGURE 11. Amount of Student Time Saved by CAI and CMI, Compared to Conventional Instruction



From J. Orlansky, "Current Knowledge and Projection on Assessing the Effectiveness of Training," Institute for Defense Analyses, 1983, p. 8.

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> studies to collect objective measures of performance of maintenance technicians on the job after training, either with simulators or actual equipment trainers. (Emphasis added.)(19)

One of the observations that Orlansky makes many times is on the incompleteness of the studies that have been done. For example, with respect to the maintenance simulators he notes that certain key studies were not done:

> Some of the presumed advantages of simulators were not examined and therefore cannot be evaluated, e.g., their ability to teach students how to correct a wider variety of malfunctions than can be done with actual equipment, their superior availability compared to actual equipment trainers, and their ability to measure and report student performance both to students and instructors....There are no cases except one where the effect of training upon job performance is examined; it found no differences between simulator and actual equipment; however, it did not report the amount of transfer of training from school to the job.(20)

The omissions mentioned would seem to be rather important matters on which the military would have wanted data. The reasons for the omissions are not because the desirability of obtaining such data were unrecognized but rather because they are just so difficult to obtain. The more variables one begins to try to examine, the more difficult it is to get valid comparative situations and enough information on which to draw conclusion. The military (and the civilian sector) have had to rely on the presumed advantages of simulators and use them when they appear to be cost effective.

Even to relate cost and effectiveness is difficult. As Orlansky notes:

> We cannot answer such interesting questions as how effectiveness might vary with cost or how cost might vary with effectiveness, because no such trade-offs have been undertaken. We have only one-point comparisons of the costs of maintenance simulators and of actual equipment trainers that have been shown to have equal effectiveness for training at school.(21)

Another complicating factor in gathering comparative data are the attitudes of the instructors -- a factor in the assessment of any instructional technology. The findings of Orlansky and String on this issue have wide applicability:

> Instructors, in general, favor the use of actual equipment, rather than simulators... Reasons given for this

> preference are that students need to train with actual equipment and that the lack of realism in simulators can interfere with effective training. Such reasons cannot be dismissed, because the views of instructors can influence the way in which simulators are used in a course: an inappropriate use of a simulator may easily make it not effective and therefore not efficient for training.(22)

Another observation about simulators can apply to almost any instructional technology:

> It may be that less expensive devices are as effective as more expensive ones for maintenance training. However, we lack both a metric and guideline to identify either the physical or functional characteristics of these devices that influence the effectiveness of training....Different levels of complexity and of fidelity may be required for the manual, hands-on skills needed in maintenance than for those which involve primarily knowledge and procedures associated with the diagnosis of malfunctions and troubleshooting.(23)

If there is this much complexity in analysing the effectiveness of maintenance training, where, one would naively think, the performance measures would be easy to specify, it is no wonder that there are few adequate studies of the use of instructional technologies for teaching more complex subjects. Much of the Orlansky-String paper on computer-based training is devoted to similar critiques of the studies in that area.

We have quoted the studies by Orlansky and String at some length in this report because we have found their analyses to be the most comprehensive and thorough of any that we encountered. We were reenforced in this judgement by findings ourselves frequently referred to their work by others whom we contacted. Their assessments of the state of studies shows that little has changed since Matthew Miles, in his seminal 1964 study of innovations in education wrote:

> A near-axiomatic statement is this: Educational innovations are almost <u>never</u> (emphasis his) evaluated on a systematic basis. Perhaps every educational researcher ought to spend part of his apprenticeship painstakingly illuminating this text on parchment:
>
> > The creators of experimental programs...have little question about the efficacy of the changes they have introduced. They <u>know</u> that the courses they have developed are the best possible under existing conditions (read "technologies" for "courses" to apply here): and in the light of this assumed fact, systematic evaluation seems superfluous.(24)

Table VI.

C. VIDEO DISK.

ADVANTAGES	DISADVANTAGES
Can deliver same images as broadcast television but without transmission cost and scheduling problem.	At present copies have to be made from master disk at special duplicating facilities. (Writable disks expected in near future.)
Can deliver same images as videotape, but provides better access to individual segments and in quantity disk is cheaper than tape.	Masters costly to produce.
Very large storage capacity — 54,000 frames per side.	Small numbers of playback devices in place now.
Any frame or segment can be accessed almost instantly.	Disk players more costly than tape.
When produced in quantity, indivdual disks are very low cost.	Master disk and copies cannot be edited or updated.
Disk virtually indestructible and laser disk never wears out.	No standards for disks or players: disks not interchangable among machines of different makes.
Can present individual pictures, pages of text, slow motion and full motion with two soundtracks.	Effective interactive programming difficult to produce.
Can be used at student's convenience: student can control pace and replay any segment.	
Can be controlled by computer to provide multi-media, interactive programs.	
Courses can be replicated without variation in content and quality.	
Has "freeze frame" capability.	
Can provide models of skilled performance.	

Table VI.

D. COMPUTERS.

ADVANTAGES	DISADVANTAGES
Cost of computers going down and capacity going up at rapid rate.	Rapidity of change in machines tends to speed obsolescence of machines, software and user skills.
Very reliable and relatively easy to use.	Costly to produce effective courseware.
Becoming widely available in businesses, educational institutions and homes.	Limited good software.
Can store and give rapid access to vast quantities of information.	Inadequate numbers of persons skilled in producing good courseware.
Essential for dealing with large quantities of data and complex symbol systems such as mathematics.	Lack of standards so that courseware not interchangable among machines.
Can be connected with each other and with many other devices, especially video disk players, science equipment, printers and telephones, permiting very sophisticated and rich learning environments.	May be impersonal and dehumanizing.
Highly interactive: permits very individualized instruction.	Many adults fear computers.
Patient, non-judgemental, impersonal, private.	Keyboard skills required for many applications and not possessed by most adults.
Student can control many aspects of course delivery: pace, timing, sequence, level, content.	Access highly dependent on socio-economic status.
Huge storage capacity permits collection and analysis of detailed records of student performance for management and research.	

Table VI.

D-2. COMPUTERS.

Presents materials at a wide variety of educational and learning ability levels — from simple to complex.

Adapts to a wide variety of settings, on the job, in schools, and elsewhere.

Courses can be replicated without variation in quality and content.

Software easy to edit and update.

Computer can be learning tool as well as tutor: can be used to teach its own use.

No ceiling on learning -- there is alway more to learn about and with computers.

Tends to increase "time on task" — a key factor in successful learning.

Usually reduces time required for achieving educational and training objectives.

As wordprocessor, powerful tool for increasing amount and quality(?) of student writing.

When connected to communication network, can give access to courses, data banks and other people.

Can simulate almost any complex system: as simulator, reduces costs, risks, time.

Effective in teaching fixed sequences of operations.

Can be used by most disabled individuals: in some cases provides only effective form of communication.

Table VI.

E. EMBEDDED TRAINING.

ADVANTAGES	DISADVANTAGES
Makes effective use of power of microchips.	High cost of initial design: must try to anticipate all contingencies.
Reduces worker memory burden.	Workers may not have time to learn when needed.
Provides training when needed.	Reduces importance of human skills.
Eliminates need to learn things that many not be needed.	Makes jobs routine and boring.
Forces designers of devices and systems to consider user's learning requirements.	Insufficiently flexible to deal with emergencies or unanticipated situations.
Reduces cost of training and maintenance.	
Assures currency of information at time of application.	

VIII. EFFECTIVENESS AND SOCIAL INTERACTION.

Over and over we heard about the importance of allowing students to have access to live instructors while using various technologies. Several attributed the success of their programs as due to the role of the faculty. "Access to live instructors was the key to student persistence and achievement," according to Nutter. "Volunteer tutors made the difference in basic skills achievement," said Hagemeyer referring to the Central Piedmont Community College basic Skills program. Feinstein and Stroebel both mentioned the importance of faculty advisors in helping their working students remain in the Wayne State adult degree program.

Several mentioned that the human factor is central in gaining acceptance of new media of instruction (Burns, Katz, Kraus) and Kraus at General Electric made the additional point that the "internal expert" at the work site is the key to the introduction of new technologies. "Find someone in a work group who already has begun to teach him/herself the new technology and who is respected by co-workers, and half the battle of acceptance is won," he said.

Not all people, of course, need the same amount of social interaction. "People whose normal activity involves other people are more likely to want to have some social interaction in their learning activities and do not do well in independent study," was the observation of Digital's Lippert. He also observed that one of the reasons that video has not lived up to expectations, whether broadcast or on tape or disk, is that there is usually no opportunity for social interaction. Using video in a group situation is one way to overcome this problem.

Several (Langner, Hughes, Lippert) also commented that, in their experience, having two students work together on a device is better than one. "Two, not one and not three," was the way that Hughes emphasized the point. "What seems to happen is that the two complement each other's strengths and weaknesses. With two working together, it is difficult for either to lang back and let the other do all of the thinking and work. With three it is always possible for one to be left out and for decisions to result from "majority rule" rather than consensus.

Finally, we heard that "students prefer traditional lectures" (Kelley, Nunns). This confirms a 1974 study (dated now) that shows the first choice of methods of learning among "would-be" learners was "lectures or classes" with 28% choosing this method and 35% actually using it. See Table VII.

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Table VII. To follow page 71.

Table VII.

Percentages of Would-Be Learners Preferring Various Methods and Percentages of Learners Using the Methods

Method	*Preferences of Would-Be Learners*	*Utilization by Learners*
Lectures or classes	28	35
On-the-job training, internship	21	14
Short-term conferences, institutes, or workshops	13	8
Individual lessons from a private teacher	8	6
Discussion groups	8	4
Study on my own, no formal instruction	7	17
Correspondence course	5	5
Group action project	5	2
Travel-study program	2	–[a]
TV or video cassettes	1	–
Radio, records, or audio cassettes	1	–
Other method	–	2
No response	4	8

[a]Less than 1 percent.

Source: Carp, Peterson, and Roelfs, 1974, p. 30.

Commenting on these findings, Cross says:

> Formal approaches to learning have their greatest appeal to those with college educations, high incomes, and high-status occupations. This suggests that those who have done well -- that is, advanced farthest in the traditional school system -- are those most in favor of continuing to use the methods that have served them well in the past....
>
> On-the-job training is usually ranked second in the methods preferences of potential adult learners....[Another study] found that adults with high school diplomas or less, labor or service workers, low-income respondents, and certain ethnic minorities ranked on-the-job training above any other learning mode.(1)

Commenting on the extremely low rating given technology-based methods in the Carp, Peterson and Roelfs study (remember that the survey was done in 1972) and similar studies, Cross observes:

> The cool reception to media-based education by adult learners is frequently cited as a reason to go slowly in the development of expensive media courses. While it is true that the electronic age has not been embraced by most adult learners (in most surveys fewer than five percent select any form of media as their first choice), two factors should be considered. First, significant numbers (from 20 to 40 percent) of adult learners indicate that television, radio, or audio/video cassettes are appropriate ways for them to learn -- even though they may not be their first choices. Second, and perhaps most important, evidence is beginning to build that acceptance of television and other nontraditional methods is in direct proportion to the individual's experience with them.(2)

That last point is particularly important as we look to the future. As technological devices, particularly computers, become more and more familiar to people, we can expect that there acceptance as learning tools will increase.

Orlansky and String found information on student attitudes towards CAI or CMI in 39 reports. Students almost always (37 times) prefer the computer to traditional classroom lectures, "or at least say so when asked."(3)

By contrast, instructor attitudes were reported in only nine studies and in only one were they favorable to the computer. We have already commented above on the importance of instructor attitudes in determining the effectiveness of technological devices. Commenting on the dearth of attention to instructors, Orlansky and String say:

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Instructors of courses taught by CAI or CMI have not received much attention by researchers. According to two studies still in draft (February 1979), only half of 54 instructors sampled in 1977 ..believe that individualized instruction is as effective as conventional instruction.(4)

Our knowledge of programs for preparing adult educators would confirm that observation. In addition, because computers are so new, there have, so far as we can determine, been no systematic studies of adult student reactions to them. Almost everyone who uses computers in instructional programs reports that adults do like them once they get used to them, but the data on the attitudes after extended use are just not yet available.

IX. INSTRUCTIONAL DESIGN STRATEGIES.

In our very first interview with Red Burns, Chair, Interactive Telecommunications Program at New York University, we heard a message that was repeated many times in various forms: "Focus on how people learn, on what is to be done and the best way to do it; do not start with technology." From others we heard that the important training technologies are not physical tools or even programs, but are the the analytical processes or procedures for determining what training is needed and how it is to be delivered and assessed. "Front-end analysis," "instructional design," "instructional systems design (ISD)," "performance management," "performance analysis," — these were the terms that we heard from consultants, researchers and practitioners who were reporting significant training results in sectors as diverse as manufacturing, film making and health care research and delivery.(1)

In the view of those who put their emphasis on analysis, trainers and educators should make use of "physical tools and delivery devices" when appropriate but should not confuse the tool with the strategies that are embodied in the tools. Prior to analysis, there should not even be an assumption that training will be necessary.

We heard many versions of this approach with varying numbers of stages or steps, but all shared the same elements: analysis, development, implementation, evaluation. We spoke to people who are implementing these approaches (Seth Liebler, Centers for Disease Control; Jack Zigon, Yellow Freight Systems; Greg Finegan, Little Company of Mary Hospital; Mitchell Fromstein, Manpower Services; Verl Dennis, Arthur Andersen Accountants; Joe Harmon, ITT Telecom; and Thomas Jenkins, DuPont).

In the view of these people, it is only after there has been a full analysis that demonstrates that lack of knowledge or skill is the factor impeding achievement of organizational performance objectives that the design of training should begin. When the training objectives have been determined, then the question of alternatives to the traditional three B's -- books, blackboards and bodies -- and their cost-effectiveness should be considered.

The cost-effectiveness analysis, as we will discuss more fully later, must take into account both the up-front costs of analysis and design and the costs of delivering instruction. Often the use of technology lowers the costs of delivery but those savings may be offset by the high costs of front-end analysis and development. Furthermore, high technology devices

and the design work necessary to use them effectively are almost always more costly than traditional modes of training delivery. Therefore, if only a small number of people are going to need the training or if the training need can be satisfied quickly by traditional means and will not recur, those means might be far more cost effective than the use of high technology devices.

However, the time and money invested up front may be more than recovered by reductions in the time required for learning, in the savings in travel costs and time away from the job, and in improved performance. A major reason is that proper analysis will assure that training focuses on just those skills that are essential to performing the required tasks and that training delivery occurs in time- and resource-efficient ways. It is under these circumstances that high technology training tools should be chosen and are most likely to prove effective.

One of the biggest mistakes many trainers make, according to the advocates of analysis before training, is to provide training whenever managers request it. Until the kind of analysis described above is done, there is no way to be certain that the problem that caused the manager to turn to the trainer will respond to a training solution. If the problem stems from such factors as poor motivation or problems with the job environment or organizational structure, training will not be of much help and may do more harm than good. We heard it said several times with the kind of assurance usually associated with laws of nature that "60-80% of the time when training is requested the problem is not a lack of skills or knowledge and therefore not a training problem."

This focus on problem solving prior to training is given renewed emphasis in the August 1984 issue of the Journal of the American Society for Training and Development by Joel Finlay, an organizational development specialists. He notes that there were six articles in the journal during the past year dealing with diagnosis in some way. The steps in the process, he says, "may appear rudimentary, but even the brightest, most strongly intuitive HRD professional might benefit from the discipline imposed by this system. In many cases, trainers jump to solutions." (2)

Seth Leibler, president-elect of the National Society for Performance and Instruction, has urged that the importance of "performance technology" be recognized in the Training Technology Transfer Act that is under consideration in Congress. Writing about the Act, he says:

> Most of the potential consumers of the tools and devices to be disseminated through the Act are unlikely to be able to perform the procedures necessary to efficiently and

effectively assess the performance problems inhibiting the achievement of their programs' missions, analyze the causes of those problems, and identify appropriate training interventions. To provide people with listings of highly complex and technical training devices without giving them access to the latest concepts of performance technology would severely inhibit the effectiveness of the Act. (3)

X: COSTS

If institutions, such as firms, schools, and colleges are to utilize new technologies to train adults, the technologies should provide at least comparable training results at a lower cost. The decisions about how to train (along with what and who to train) depend directly on an assessment of the costs as well as the effects of training.

Not all of our contacts in firms, schools and colleges believed the new training technologies were less costly than traditional classroom-type instruction. For example, the Fashion Institute of Technology (in New York City) is heavily committed to the use of technology in instruction, but the Institute's President Feldman says that "there is no cost advantage in technology." It is much more costly to provide instruction on and about the new textile technology than it was to train for the older technology. But, it has simply become necessary to use the new technologies in training because of the ongoing and projected changes in the workplace. "The critical factor now is design, and it takes high quality instruction using the best possible training devices to produce the kinds of designers that the industry needs. I have a tough time," Feldman laments, "convincing my funding agencies that there will be future pay-off for those high costs." And, while he has been able to secure funds for equipment, he has been far less successful in generating funds to hire the people who must operate the equipment and use it effectively.

Others, however, claimed to have clear evidence that new training technologies saved money as well as being at least as effective as traditional training methods. The cited evidence often consists of a presentation of the costs of training undertaken with a specific technology (with explicit or implicit references to the costs of training under alternate training approaches). Other reports and sources offer limited cost-effectiveness evidence. We found relatively few estimates for programs directed toward adults in the U.S., and particularly at the job site. Wilbur Schram's 1977 volume, Big Media, Little Media, summarizes most of the studies and reports of costs through the mid-1970's. He finds the analyses generally addressed the introduction of technological devices in elementary and secondary education, with some of the most detailed studies drawn from applications in developing countries. In our judgement, the situation has not greatly changed.

Some of the available material we reviewed is summarized in Tables VIII and IX. Although not comprehensive, the listings display the range of available studies and the estimates and evaluations of costs and cost-effectiveness.

Table VIII to follow page 77

Table VIII

Estimates of the Costs of Training with Technological Devices

Site (source)	Learners	Purposes	Findings
TELEVISION			
Open University, United Kingdom (Wagner 1982) a free-standing institution providing college courses via TV, radio, and learning centers	Adult College Students	Degree-Credit	Reduces cost per graduate by two-thirds (direct costs); Traditional lectures require one-tenth the fixed costs, but more than twice the variable costs; Traditional students incur opportunity costs ten times greater than Open University students (due to part-time attendance);
Everyman's Univ., Israel (Melmed et al, in Perraton 1983) same program and structure as the Open University	Adult College Students	Degree-Credit	Reduces cost per graduate by one-half; Considers foregone income of students;

Table VIII, continued

Estimates of the Costs of Training with Technological Devices

Site (source)	Learners	Purposes	Findings
COMPUTER-BASED			
PLATO IV (Wagner 1982)	College Students	Degree-Credit	Reduces cost per stu- by two-thirds;
computer-based college course modules delivered from a central, main frame computer to terminals at satellite sites			Development represents one-third of total cost of instruction;
			Initial cost estimates per student hour "too low" due to underestimate of development costs and overestimate of use rate;
General Electric (Hart nd)	Employee Training	Skill	Development cost per hour of instruction ranges from $2300 to $28000;
Military (Orlansky and String 1979)	Military Training	Skill	Review of 30 studies; 8 with cost data.
			Cost data "incomplete" (no data collected or presented on 5 of 13 identified cost components;
			CAI, CMI results in a 30 percent reduction of time in training;

Table VIII, continued

Estimates of the Costs of Training with Technological Devices

Site (source)	Learners	Purposes	Findings
VIDEO-CASSETTE			
Univ. of Surrey, United Kingdom (Gilbert and Monaco, in UNESCO 1980)	College Students	Degree-Credit Laboratory Course	Development represents 50 percent of life-cycle costs; Equipment represents 15 percent of life-cycle costs and 20 percent of start-up costs;
Digital Equipment Corporation (Lippert)	Company Personnel	Skill	Development cost per hour of instruction averages $15,000-$16,000; No estimate of recuring or delivery costs
SIMULATOR			
Manpower (Fromstein)	Temporary Secretarial	Skill	Development cost of $6 million; No estimate of recuring or delivery costs
Military (Orlansky and String 1981)	Military Technicians	Skill	Review of 12 studies, with detailed cost analyses; Excluding delivery, 80 percent of costs are non-recurring; Analysis, design, development accounts for one-half of costs of putting simulator on-line.

Table IX to follow page 77

Table IX

Estimates of the Cost-Effectiveness of Training with Technological Devices

Site (source)	Learners	Purposes	Findings
VIDEOTAPE			
ITT-Telecom (Harmon)	Engineers Technicians	Introduction to new Equipment	Reduced time to completion by three-fourths;
Digital Equipment (Lippert)	Company Personnel	Skill	Cost-effective if 300 students resame course within three years;
COMPUTER-BASED			
Motorola (Goldwater)	Employees	Skill	"20-30 percent more cost-effective than using on-site classroom instruction;"
IBM (Munns)	Service Personnel; Assemblyline workers; Engineers	Skill	CAI less costly for 100 or more students;
Military (Orlansky and String 1979)	Military Personnel	Skill	Reviews 30 studies; none provide adequate cost-effectiveness data;
SIMULATOR			
Manpower (Fromstein)	Temporary Secretarial	Skill	Recovered development costs within 18 mos.
Military (Orlansky and String 1981)	Military Technicians	Skill	Reviewed 12 studies; one contained suffidata to conclude that simulators train as effectively as actual equipment for 38 percent less.

Table IX

Estimates of the Cost-Effectiveness of Training with Technological Devices

Site (source)	Learners	Purposes	Findings
SIMULATOR			
Manpower (Fromstein)	Temporary Secretarial	Skill	Recovered development costs within 18 mos.
Military (Orlansky and String 1981)	Military Technicians	Skill	Reviewed 12 studies; one contained suffi- data to conclude that simulators train as effectively as actual equipment for 38 per- cent less.

Table VIII contains summaries of reports on the costs of training adults with new technologies. The cost estimates vary widely in detail and magnitude, even for training programs utilizing similar devices (eg., computer-based). The differences in estimated costs (where comparable) may be attributable to the type and duration of training, the numbers of individuals trained, and the particular uses of the device employed.

Table IX contains the reported estimates of cost-effectiveness, identified by type of device. Although the figures are not strictly comparable, the firms, schools, or colleges with some information do find evidence of cost-effectiveness across a variety of settings, program purposes, clientele, and devices.

In spite of these estimates, we come away from our reviews of the reports and interview data with the impression that most firms, schools, and colleges simply do not have adequate, competent estimates of what it costs to provide training to adults (under current or alternate approaches). The figures provided to us appear to be little more than crude "back of the envelope" calculations of costs or cost-effectiveness. This assertion also reflects the general impressions of Columbia University's Richard Anderson, one of the few researchers to probe deeply into the costs of adult education and training within and outside of colleges and universities. In a personal communication, Anderson expressed the view that relatively few firms have yet embraced new training technologies. This, coupled with his recent findings of inadequate attention to a full accounting of all of the costs of training throughout the education and training sector (in Anderson and Kasl 1982), simply reinforces our view that good cost (and cost-effectiveness) data do not exist.

We would add, however, that the estimates of gains to training reported in the corporate settings are so large, relative to crude measures of costs, that errors in the cost estimates would not likely alter the general conclusion that the use of devices in most of these instances are cost-effective (at least in the sense that they result in savings on training and gains in productivity greater than the costs of training with technology).

1. Reported Costs of Training

During our interviews and reviews of documents and reports, we found a number of firms, colleges, and schools which had developed and reported estimates of the costs of their training efforts. Most frequently, the firms reported (1) equipment acquisition costs; (2) recurring maintenance and delivery costs; or (3) some estimate of the value of employee time in training. Seldom were all three included, and most of the reported figures were inappropriate.

The basic approach to developing appropriate measures of costs and effectiveness has been widely-used in evaluations of a variety of education and training programs (see, eg., Levin 1983; Wagner 1983a and 1983b; Anderson and Kasl 1982; Jamison 1977). In this approach, training can be viewed like any other economic decision. When training is called for, the firm, college, or school should allocate resources (training inputs) to the option which best (most efficiently) achieves the desired skill levels. This approach offers a consistent and appropriate way to identify all of the specific resources allocated to training, requires analysts to clearly state the assumptions underlying the measurement of these resources (in quantities and dollars), and permits cost comparisons among alternative training options. Although this is not an easy task, a careful assessment of the inputs used in training and their value to the firm is essential to decisions about whether and which technological devices should be utilized in training programs.

The following illustrate the dimensions and nature of some of the key elements in the development of appropriate cost measures and suggest some of the flaws we uncovered in the figures reported by firms, schools, and colleges:

FIRST, all relevant inputs should be included. The inputs include training designers and evaluation specialist services (their time), instructor or supervisor services (their time), support and administrative services (their time), equipment use (utilization of on-line or specialized training equipment), supplies and materials, facility use, and trainee inputs (their time and added training expense). Frequently, studies of training costs omit one or more of these inputs altogether. For example, a firm may report only items in the training budget (instructors, specialized equipment), but not include trainee time. From a variety of studies, trainee time may account for as much as one-half of the costs of training. Orlansky and String (1981) note that many of the studies of computer-based instruction contain "generally incomplete" cost data, since they exclude the costs of trainee time as well as other recurring costs.

SECOND, appropriate measures of the use of each input must be estimated once the relevant inputs are identified. When training serves more than one specific objective (say, employee "compensation" as well as improving specific job-related skills), only a portion of the activity (and its associated expenses) should be allocated to training. Moreover, the quantities of "shared" inputs such as indirect support services, space, and production line equipment used in training must be estimated. Again, most of the studies ignore some or all of these measurement questions, including or excluding inputs according to a particular firm's or researcher's way of adding up costs.

Importantly, the differences in detail and measurement are, by themselves, revealing since they indicate the judgements of firms (researchers) about which resources should be included (and excluded) in developing training costs. But, these judgements need to be made explicit; different judgements about how much of these inputs should be allocated to training may alter the ranking of training options.

FINALLY, once inputs have been identified and measured, total costs are obtained when the prices of the inputs are applied to the quantities utilized in training. For some inputs, the prices are directly observeable (a wage rate for instructors or trainees; telephone transmission rates). For others, the implicit prices must be inferred from other sources (eg., cost per square foot for facility use and depreciation or use rates per hour for equipment). But, here, the appropriate price should reflect the value to the firm, college, or school in alternate use. For example, if the firm or college owns empty space or idle equipment that cannot be leased or sold easily, the value of these items in alternate uses is close to zero. This would be the case for a college with enrollments of "regular" students falling below the capacity of the physical plant, or a school with facilities used only during the day. A firm that experienced seasonal fluctuations in demand for its product or services might also face similar excess capacity conditions. During low demand periods, the price for applying idle space and equipment (and even staff or employee time) to training would be quite small. Alternatively, the price of using a highly talented supervisor for training during periods when the demand for the product is high might well be prohibitive.

The pricing of durable inputs such as facilities or equipment raises additional problems. The firm, school, or college must project the period over which the relevant training will take place, and compare alternate training methods (with and without technological devices) over that period. Thus, the institution needs to calculate the present value of all costs in the initial year(s)--design, acquistion of devices--and in later years--trainee time (if appropriate), supervision, and maintenance of courseware--FOR EACH TRAINING APPROACH. It is these total present value costs which must be compared, relative to the expected results of training.

This total cost approach emphasizes two critical elements of using technological devices in training. First, the institution must know the DEVELOPMENT AND ACQUISITON costs as well as DELIVERY costs for each option. Orlansky and String (1981, p.64), among others, emphasize attention to these total costs and fault the available studies precisely on this basis. Second, the institution must be able to estimate the VOLUME of training, including the period over which the relevant training

will take place. Costs per trainee fall markedly with increases in volume, as many of our sources indicated (L. Wagner, Lippert, Harmon).

Importantly, if a training program will be used for a large number of students (or for a greater number of years), the high initial development and acquisition costs might be more than offset by substantial accumulated savings on employee or instructor/supervisor time in training. According to Orlansky (1982), initial, non-recurring costs for simulators account for about forty percent of the costs in this training approach. In part because the simulators will be used in training for a projected ten years, the savings on the time of training for trainees and supervisors and on the use of on-line equipment would be expected to more than balance what appear to be high initial outlays. Gilbert and Monaco's 1980 evaluation of the use of videotapes in a college laboratory projects substantial savings on regular instructors, principally because the videotapes will be used, with slight modification, for 12 years. Motorola claims "computer based training was 20-30 % more cost-effective than using on-site classroom instruction or outside colleges and trade schools," presumably in part because of savings in trainee time over a sufficiently long period of training.

Alternatively, if the number of students to be trained (or the number of years over which a training program is to be used) is relatively small, the use of expensive training options with high one-time development and/or acquisition costs may be more costly than more traditional, supervised training administered by supervisors. Institutions expecting a rapid obsolescence in necessary skills (due to new innovations or even high labor turnover) might choose less expensive training technologies and devices since the specific training program would be in use for a relatively small number of people (or for a relatively short period). Frank Hart of General Electric observes that older, less costly computers have proved to be adequate for some of their training applications. The implication is that firms need not adopt the most recent technological devices to achieve the desired results; in the process, the firm will likely save money on training costs. Firms anticipating obsolescence of skills are making use of a second way to make particular technologies pay. Some, such as Manpower, are investing substantial amounts in a training technology that is easily modified to permit the development of newer skills. The latter option essentially extends the number of years or trainees over which a particular training technology can be used.

2. Illustrative Costs of Training with Technological Devices

In Table X, we offer illustrative case study estimates of the costs of training incorporating different technological

Table X to follow page 81

Table X

Illustrative Costs of Training with Techonological Devices
(per student hour)

	Employer-Provided[a]	CAI/CMI[b]	Simulator[c]	TV-Based[d]	Video-Cassette
Total	$41.70			$ 8.74	
Non-Recurring					
Development	2.49	$ 3.11	9.18	1.59	6.87
Acquisition	1.44	3.85		1.38	2.40
Recurring					
Operations	9.19	4.26	19.13	4.15	5.42
Trainee	28.58	unk	5.52	1.62	unk

Where quantities or non-U.S. monetary quantities are reported, these have been crudely converted to approximate U.S. dollar equivalents. Estimates are not directly comparable, since they apply to different time periods.

[a]Estimated from case study data provided in Anderson and Kasl (1982), for a general technical training program at an information processing firm. The program has about 900 participants averaging 280 hours of instruction.

[b]Estimated from teaching laboratory data compiled at the University of Surrey (U.K.) by Felden and Pearson (1978). The program consists of 10 terminals tied to a mainframe computer, averaging 5500 hours of use each year.

[c]Estimated from Orlansky and String (1981) from data reported for 6883 Test Bench simulator. About 180 students per year undergo 3 days of training with the simulator, over an estimated 15 years. Costs for equipment beyond initial implementation is included in recurring costs (and accounts for over half of the estimated operations costs). Figures are <u>not</u> discounted, so the magnitude of recurring costs is overstated.

[d]Estimated from Melmed et al (in Perraton 1982) for Everyman's University in Israel. Data refer to a mixed media program enrolling 6,700 students for an estimated 108 hours of instruction each year.

[e]Estimated from Gilbert and Monaco (in UNESCO 1980) for University of Surrey (U.K.) physiology laboratory class serving about 100 students each year.

devices. The estimates come from specific training studies, and are flawed in many of the ways just discussed. Furthermore, the data are not strictly comparable. It is inappropriate to compare, for example, the per student hour cost of training using a simulator with the per student hour cost of using video-cassettes since these devices would not typically be used for the same training purposes, populations, or volumes. This last caution would apply even if the estimates shown here had been developed from the consistent, adequate approach to costing described above.

With these caveats in mind, some general inferences may be drawn from the data. FIRST, the estimates reveal wide variation in the costs per hour of training. The differences might be attributable to underlying differences in the purposes, sites, scale, and trainee characteristics for the examples selected here.

SECOND, the training applications involving heavy use of technology do appear to incur relatively larger non-recurring, initial costs. For comparison, in the general employer-provided training program shown in the first column, development and equipment acquistion costs are about half as great as operations costs per trainee hour. The video-cassette application shows non-recurring outlays some 70 percent higher than recurring, operations costs.

THIRD, where there is no apparent shift in the composition of costs (as in the TV-based training/education example shown here), the incentives to incorporate even limited use of the new technologies may result from the relatively large potential savings in student support and opportunity costs (reduced by as much as 80 percent compared to traditional delivery of instruction). These considerations are not revealed in Table X, but are be apparent when the TV-based and more traditional, classroom instruction are compared.

FOURTH, these estimates likely do not reflect the structure of costs today, given the dramatic improvements in technological devices (which drive down acquistion and some delivery costs), along with the relative increase in trainee costs. The net results, in terms of costs, would seem to continue to favor further introduction and expansion of technology in training--a point to which we now turn.

XI. EDUCATIONAL CHANGE: BARRIERS AND INCENTIVES.

When one surveys the extent and character of the use of technologies in the education and training of adults today, it is possible to take have two quite conflicting reactions. On the one hand, given the benefits that are supposed to come from the applications of technology to education and retraining, one might be surprised at the relatively limited use of technology. There are no firm figures on this, but our strong impression is that still the overwhelming proportion of learning and training time of adults is spent with traditional modes of delivery: classrooms and books. We have suggested some of the reasons for this situation in Table XI, which lists the major barriers to the wider use of technology.

On the other hand, given how little hard evidence there is for the superiority of technology-based instruction over traditional, one might be surprised at how much of it there is. The numbers of governmental agencies, private sector firms, schools, colleges and universities that are making major commitments to the use of technology for education and training is going up and accelerating.

Yet change in education is notoriously slow. For the "classical view" of just how slow that process is C.P. Snow's ironical comment, quoted by Matthew Miles in his seminal study, on innovation in education:

> In a society like ours, academic patterns change more slowly than any others. In my lifetime, in England, they have crystallized rather than loosened. I used to think that it would be about as hard to change, say, the Oxford and Cambridge scholarship examination as to conduct a major revolution. I now believe that I was over-optimistic.(1)

While change in education may not be quite as difficult to bring about as Snow suggests, Miles notes that studies by Paul Mort and others in the 1930's showed that "the complete process of adoption of an innovation appeared to occupy a period of about 100 years." Miles added, "It seems clear that present diffusion rates are <u>much</u> more rapid than these." (Emphasis his.)(2)

That was written in 1964 when public policy was just beginning to support systematic innovation in education.(3)

While the general barriers that make for slow change in education are still at work, as we suggest in Table XI, most of the barriers to the adoption of technologies in adult education and training are likely to decrease in the near future, thus accelerating the pace of change. We have grouped the barriers into three categories: costs, attitudes, and effectiveness.

Table XI. To follow page 83

Table XI

Barriers and Incentives to Adopting Technology in Training

Barrier	Technologies Most Affected	Likelihood* of Change	Factors Influencing Trends
COSTS			
Hardware	mainframe computers	(D)	all hardware costs are declining due to large-scale production and technical innovations
	video disk	(D)	
	broadcast TV	(D)	
	embedded training	(I)	pace of technical change increases obsolesence and reduces volume over which hardware costs can be spread
	all	(I)	pace of technical change favors adaptable training approach, i.e., people over fixed device
Course Development	computer-based	(I)	complexity of material to be taught; increased quality expectations;
	television	(I)	
	video disk	(I)	
	all	(D)	better authoring and development aids; large-scale development; reduced time in development; more experienced development personnel
Program Delivery	broadcast TV	(D)	increased availability of cable and direct broadcast satellites; deregulation; decrease in component cost; greater efficiency in use of affected technologies
	computer conference	(D)	
	audio conference	(D)	
	computers	(D)	decline in price and increase in supply widens access (limited for disadvantaged, unemployed, isolated, and immobile)
	video tape/disk	(D)	

Table XI, continued

Barriers and Incentives to Adopting Technology in Training

Barrier	Technologies Most Affected	Likelihood of Change	Factors Influencing Trends
COSTS			
No Standardization	Computers Video-disk	(I) (I)	Market-place competition; De-centralized authority in firms and educational institutions;
Piracy	computers video-disk	(D) (D)	Better copyright and hardware protection; Reduced profit incentive for pirates; Increased support and post-acquisition service
Financing	all	(D)	large front-end costs reduced with improvements in equipment and courseware; courseware design allows for inexpensive improvements and larger volume of training; relative costs of technology-based training falls as travel and trainee time costs rise
	all	(I)	funding at colleges and universities lags; resistance to using venture capital for training technologies; limited R&D funds

Table XI, continued

Barriers and Incentives to Adopting Technology in Training

Barrier	Technologies Most Affected	Likelihood of Change	Factors Influencing Trends
EFFECTIVENESS			
Course Quality	all	(D)	more trained in instructional design; better authoring and development aids; more research on learning and instruction; better replication;
Learner Differences	television	(D)	more two-way, self-paced, interactive, multi-media applications
Instructor Contact	all	(D)	more "personalization" of courseware;
Inappropriate Use	all	(D)	more experience with technology-based training; realism, awareness of limitations;
	video-disk	(D)	reduced use of "off-the-shelf" courseware;
	computer	(D)	greater flexibility in customizing courseware
Scheduling	television	(D)	greater availability of cable and satellite time-slots

Table XI, continued

Barriers and Incentives to Adopting Technology in Training

Barrier	Technologies Most Affected	Likelihood of Change	Factors Influencing Trends
ATTITUDES			
Trainee Fears	computers	(D)	aging of "computer generation;" increased contact with computers everywhere; advertising; more computer-literacy courses; more "user-friendly" computers and courseware;
Trainee Motivation	all	(D)	more job incentives for continued learning; better course materials; more attention to motivation in course design
Trainer Fears	all	(-)	belief in human contact; slowness to change
Management Fears	all	(D)	more experience with technology-based training (cost; effectiveness)

*Assessment of likelihood of change in barriers to utilization. In most cases, the change reflects a reduction or increase in the barrier itself. In some instances, the barrier is overcome by related incentive to adopt a particular technology. (D)=decrease in barrier; (I)=increase in barrier.

Costs have always been cited as a major barrier to the introduction of any new technology in any area of human endeavor. The reason is easy to see: an up-front investment has to be made to get anything new started; while the costs of installing the old ways have already been paid and the costs of continued use are generally low. It is only when the longer-term costs of the new and the old are compared that the cost advantage of the new, if there is one, becomes apparent. However, to obtain that longer-term benefit, those up-front costs must somehow be covered. Individuals and institutions that have restricted resources are going to find those costs a greater barrier than institutions that have access to greater resources.

Two developments are converging to lower the cost barrier to the adoption of technology for training: the cost of most of the components of technology are going down — in the case of computers, down dramatically; and the costs of traditional alternatives are mostly going up.

The one component of technology that is not likely to drop in absolute terms is the cost of development of quality programs. As there are increases in the complexity of training requirements and in the expectations of learners for highly motivating (entertaining?), time-conserving and effective programs, the costs of development will increase. These increases will be only partially contained as a result of the application of findings from research on learning and teaching and improved development aids, such as authoring programs and computer graphics systems. It is to be hoped that the benefits from improved training systems will outweigh the increased costs of development.

But even if the overall costs of using technology drop significantly, there is still going to be the need for some up-front money to buy the hardware and software, make facility adjustments, and train staff. Institutions that cannot acquire that up-front funding are still going to continue to face the cost barrier.

One factor that may reduce the pace of adoption of technology to training is the very rapidity of the changes in technology. In order for technology-based training to be cost-effective relatively large numbers of people must need to receive the same training over a fairly restricted time period. However, if changes in technology change skill and knowledge requirements and thus make the training obsolete, using traditional training procedures may be more cost-effective. Instructors and print materials can be more readily changed than can most technology-based programs.

Attitudes have also been barriers to the adoption of new technologies. Fear of the unknown and apprehension about how the

new will affect one's current status and future security are powerful emotions. They are certainly at work in inhibiting the spread of technology in adult education and training. Other attitudes that affect acceptance are resistance to any change, disbelief in the value of the new, and fear of exposing one's inadequacies, particularly if the person is supposed to be highly competent. These attitudes are held in varying degrees by administrators and managers, instructors and trainers, and students.

Whatever their roles, adults are thought to be more resistant to technology in education than children. However, a number of the interviewees reported seeing dramatic shifts in the attitudes of adult learners in recent years. Computers in particular seem less and less to be devices to be feared and avoided.

The attitudes of two groups are likely to continue to be significant barriers: managers and school, college and university faculty.

Many managers are skeptical of the value of training. They know that employees usually like it; they hope it won't do any harm and might do some good, but they are not really convinced that it is worth much effort or investment. With that attitude they do not expect much from the training they do suppport, and so seldom make the effort to hold the training department accountable for results. If they ask for training to solve problems and the problems persist, that confirms their low opinion of training.

Such managers are not likely to make the investments necessary to use technology effectively for training. To be sure, if they perceive that using technology is the "thing to do," they will do it. That is more often than not likely to mean buying the latest training equipment, rather than careful assessments of training needs and investment in a full-scale development program. Organizations with those attitudes at the top are not likely to see effective use of technology in training.

The other group that is going to remain a significant barrier to wider application of technology in adult education are the faculties of many colleges and universities. What we heard was not so much resistance based on faculty fears for their own jobs, but rather resistance because of restricted resources available to the institutions. As Hoelzl put it, "There are so few resources, faculty resent any diversion to new programs when existing programs are underfunded."

Another faculty concern with the new technologies, in the view of Marvin Feldman, president of the Fashion Institute of

Technology in New York (FIT), is with control. Faculty, he found, will not use technologies that appear to take away control over instruction. An indication of this attitude was reflected in what Feldman had to do in order to get computers fully integrated into the entire curriculum at FIT. Departments were not willing to turn over training in computers to a centralized computer science department, or even let decisions on what computers to acquire be made centrally. However, when each department was authorized to acquire and use computers as seemed best to meet its needs, computers spread throughout the curriculum — without, of course, any standardization on brands, software or procedures for use.

Another faculty attitude found in the military studies cited earlier was that technology-based instruction was just not as effective as traditional. So long as faculty have that view, they can make it almost certain that, in the long run, technology is not going to be accepted.

The effectiveness or, rather, the lack of effectiveness, of available technology-based training materials is another alleged barrier to their wider use. "There isn't anything good out there that meets our needs," or "We tried it and it didn't work," are sentiments that keep some organizations from using more technology in their training.

However, the cry of low quality is easy to make and hard to substantiate, particularly because there is so little good data on the effectiveness of most technology programs. Thus, it may well be that this concern is really another attitudinal barrier. People who do not believe that technology can contribute anything useful to training, may not make the effort to apply technology effectively and instead use the alleged lack of quality as a reason for not trying. For effectiveness is not an absolute: it is the attribute of a program that does what it is supposed to do better than available alternatives in a cost-effective manner. One program may fully meet this standard for some organizations and totally fail to meet it for other organizations. In short, judgements about effectiveness have to be made in relation to specific situations.

But apart from the question of the relativity and subjectivity of judgements, it can be anticipated that, however judged, the effectiveness of technology-based training will increase for reasons that are indicated in the table. As individuals and organizations gain experience with technologies, they will learn what works and what doesn't. More and more people are gaining such experience and some colleges and universities have or are initiating programs to train specialists in instructional systems design and implementation.

The most powerful factor that will insure increased effectiveness comes from the nature of the technologies themselves. All of them, except live television and radio, are recordable and replicable. This means that everything can be reviewed, judged, changed and improved. Differing versions or approaches can be tried and the results compared. And, when a product judged effective is produced, it can be used over and over without degradation — a feature that most strongly differentiates technology-based instruction from instructor-based. No matter how good an instructor may be, it is hard to maintain the same level of quality all the time, and even harder to pass on those characteristics to someone else teaching the "same" course.

The computer adds another component to the quest for effectiveness. It is not only a replicable medium like the other technologies, it is also a data collection instrument. Moreover, that data, if desired, can be collected totally unobtrusively. The computer can collect and help analyse vast quantities not only of outcome data, but also, and, for development purposes, as important, formative data, i.e., data on how the program is working — how long students spend working with it, where they are having problems, what seems to be too easy, etc.

There are several barriers to wider exploitation of this power of the computer:

1. The very volume of data that can be generated is intimidating to those who do not know how to handle it. Quantity of data will not by itself produce understanding.

2. There are not enough people trained to use the data constructively.

3. One reason there are not more such people is that the entire emphasis both among producers and users of training programs is on production of programs. We found very few organizations that seem to be devoting much effort to research in their development efforts.

Another factor inhibiting the full exploitation of computers in education is the lack of standardization. "One of the major barriers to wider use of technology in instruction is the lack of standards," according to Sharon Fisher of the Institute for Human Technology. Trainers would like to make greater use of the microcomputers that are proliferating in most organizations. However, in most organizations there is no standardization on micros so that it is difficult to produce programs that can be used by any significant numbers of people in the organization. There are, according to Fisher, people in the Department of Defense who would like to standardize computers, video disk systems and authoring languages, but they are not optimistic about that happening anytime soon.

What appears more likely to happen than the early adoption of standards is, first, the readiness of developers of successful programs to adapt them for all of the more popular machines. Every software and courseware producer now tries as quickly as possible to market an IBM and an Apple version of successful programs. As the population of machines grows, this will become an increasingly attractive option whether for computer programs or video disk.

A second development will be the emergence of translation programs or devices that will permit programs designed on one system to run on others. Because of variations among the machines, this approach will never work for all programs, but it may help with the portability of some kinds of courseware.

Given the foregoing assessment of barriers and incentives to the uses of technology in the education and training of adults, which of the two is likely to prove stronger, the barriers or the incentives? Before answering that question, it should be instructive to look at some earlier history in the effort to apply technology to instruction.

XII. INNOVATIONS IN EDUCATION: LESSONS FROM HISTORY.

Even before computers came on the scene, educators and trainers were experimenting with ways to improve the instructional process. In the twenties Sidney Pressey at Arizona State University first developed the concept of programmed instruction and the "teaching machine". Although these concepts have largely passed from the educational scene, except as they have been reincarnated in computer assisted instruction, the story of programmed instructions teaches some important lessons about the introduction of new technologies in adult education.

Pressey's basic assumption was that people learn best when new material is presented in small, sequenced steps and are given immediate feedback on how well they have understood the new material. In his programmed approach, small amounts of information were presented, the student was given an exercise, which could be as simple as filling in a blank in a statement, and then told immediately whether or not the response was correct. An incorrect response led to a remedial exercise so that the error would not be reenforced.

Pressey expected his machines to produce a "coming industrial revolution in education." However, he was disappointed in the response to his work and largely gave up work on them after a few years.

Pressey's work was extended and given theoretical psychological underpinnings by B.F. Skinner at Harvard in the 1950's. The essense of his approach was his conviction that any behavior can be produced by reenforcing or rewarding closer and closer approximations to it.(1)

At first the programmed approach was tried in book form. In a typical format, small amounts of information were presented on a page followed by a question or exercise to test understanding of the material. The student was given two or more choices and directed to another page on which feedback on the choice was given. If the student's response was correct, s/he would be directed to new material; if it was incorrect, an explanation would be provided of why the choice was wrong and the student would then be directed back to the original page for another attempt.

The student who answered every question correctly would go straight through the material in a "linear" fashion, while the student who made errors would be "branched" to remedial material. In this way it was believed, programmed instruction could be highly individualized. The able student would go through the material quickly, the less able student would take more time, but both, by the end of the program, would have achieved the same level of mastery.

Research studies initially demonstrated dramatic improvements in learning compared with conventional approaches. It soon became apparent, however, that the book format was cumbersome to construct and use. Developers therefore turned to mechanical or electrical devices. In those early "teaching machines" the material was stored on slides that would be projected on a screen. The student had a number of buttons to use to make selections among the alternative choices. The device was "programmed" to choose the appropriate next slide, based upon the student's choice. In more sophisticated devices, records would be kept of student progress through the material so that developers could tell easily which items were giving students the most trouble. By 1962, over 80 different teaching machines, some computer controlled, and 630 instructional programs were commercially available.

An "ideal" program would be one in which all students would go through the material in a linear fashion since every step would be mastered and understood before the student would proceed to the next. This feature led many critics of programmed instruction to point out that well constructed textbooks would do as well as programmed materials, and they proceeded to demonstrate this in their studies.

Like so many new technologies in education, programmed instruction was at first greeted with a great wave of enthusiasm. Skinner himself in 1954 (only 30 years ago!) proclaimed the dawn of a new era in education:

> We are on the threshold of an exciting and revolutionary period, in which the scientific study of man will be put to work in man's best interest. Education must play its part. It must accept the fact that a sweeping revision of educational practices is possible and inevitable.(2)

In 1957, Simon Ramo, one of the founders of TRW, described how "teaching engineers" with pushbutton classes and memorizing machines could help meet the increasing need for more education in a growing technical society.(3)

In 1966, in testimony before the Congressional Subcommittee on Economic Progress hearing on "Technology in Education," Kurland spoke in glowing terms about the future of technology in education based on what he had already seen in the schools.(4)

However, these rosy prognostications ran up against some harsh realities. It turned out to be more difficult than originally presumed to construct reasonably priced machines that would stand up reliably to day to day use in classrooms. But even more serious was the difficulty of producing large

quantities of effective instructional materials for them. Formats that were easy to use, such as statement, questions and limited branches, could not hold student attention for any extended periods of instruction. More challenging formats were difficult to implement on the available devices. Moreover and, more seriously, it was soon discovered that, as the complexity of the material increased, so did the numbers of branches required to enable any significant numbers of students to progress through the material without ever running into "closed loops" where there were no remedial branches to deal with their learning difficulties.

Still more seriously, programming seemed to work best in situations where the learning outcomes could be specified in precise terms and the motivation to learn was strong. This description fits training better than education, so it is not surprising that the most extensive use of programmed instruction was in industry and the military. But even there, the passive role into which the student was put by most programmed instruction militated against effective learning. Programs were too rigid and inflexible and the whole approach bored too many people. Students, particularly adults, need opportunities to express concepts in their own words and take an active part in the acquisition of new knowledge and skills.

All of these difficulties reenforced the general resistance in education to any new practices and so programmed instruction and teaching machines were rapidly disappearing from the educational scene by the late sixties. At that point,

> prophets of a technological revolution hitched their hopes to a new star. Individualized instruction was the technology that was to change the shape of education. Like programmed instruction, individualized instruction emphasized individual work, self-pacing, and the achievement of mastery, but it used longer instructional units — often called learning activity packages or modules — and gave learners freedom to choose among different means of achieving precisely specified educational objectives....Such systems received a great deal of attention while the federal government was supporting their development and dissemination, but with the drying up of federal funds for educational research and development in recent years, interest in such systems has declined also.(5)

Still another technology that was going to revolutionize education was the 8mm film. In 1964 when the Miles book on innovations in education was written that was the "hot" educational technology. Louis Forsdale's chapter reads just like current discussions of video disk and computers.(6)

8mm projectors were at last going to bring motion pictures to the classrooms of America — over 50 years after the

motion picture had become commercially available and nearly 40 since sound had been added. Speaking of educational film, he wrote, "Is it not destined, in its maturity, to serve (like the book) as a ubiquitous medium of truly central importance in education?" (p. 205. Emphasis added.) The factors leading to this optimism sound familiar: "convenient size, lowered costs, strikingly simplified new projectors, ease of use in individual classrooms, new types of film, and publishers beginning to produce 8mm films for classroom use."

To spread the new technology Teachers College in New York City established in 1960 a Project in Educational Communication. It sponsored a "major conference" on 8mm film in education in November, 1961, which was attended by 150 "leaders in the audio-visual field, with representation about equally drawn from the photographic industries and education." In all likelihood, most of the educators were themselves from audio-visual departments, just as today's conferences on computers in education are likely to be attended by "leaders" from the computer industry and computer science and education departments.

The only possible competition to 8mm that Forsdale could foresee was video tape. However, because the players had come down in price to "only" (his quotes) $15,000, he thought it had "little chance of competing with 8mm film in cost, quality (including color), and ease of use."

As Forsdale looked to the future of the 8mm projector he saw that "the revolutionary nature of this machine, at its low price, will not be denied." He was bolstered in his optimism by the results of a 1962 survey done by the National Film Board of Canada, that he cites, in which 94 out of the 100 respondents thought that "8mm sound film would be available for general classroom use before a decade was out, with the majority of respondents feeling that this would occur within four years." (So much for those prognosticators -- but this has to have been one of the most unscientifically conducted surveys one can imagine. Unfortunately, it is all to characteristic of surveys on which many projections in education are based.)

Not only is this bit of history instructive for what it says about the ability of supposed experts to predict the direction that educational innovation and technology will take, it also is a reminder that there is a difference between devices and processes. The 8mm film and projector were devices that Forsdale and others confused with the process of using moving visual images to help convey information and provide instruction.

As we have seen, the expectation that visual images can play a useful role in education and training is far from dead. Educators and trainers are still looking for the delivery system

that will make it easy to employ visual material in instruction. It may be that the video disk, or the computer which integrates text, pictures and sound, will be it. It should also be clear, that more important even than the device, is the understanding that is required about how to use visual material to promote learning. It may well be that it is the failure in that regard more than lack of appropriate devices that has been the cause for the slow diffusion of motion pictures, whatever the carrier, into education and training.

As we reflect on this history, it is well to remember that when computers first began to come in widespread use they too were hailed in terms very similar to those used for earlier instructional technologies. Many saw in them the possibility of finally producing the kind of "teaching machine" that had thus far eluded the followers of Pressey and Skinner.

Typical of the hopes then expressed was the comment of Charles Silberman, one of the most widely known educational observers in the sixties, who wrote in 1968:

> Computers and their associated electronic gadgetry offer ways of remedying some of the obvious defects of programmed instruction. What makes the computer a potentially important — perhaps revolutionary — educational instrument is precisely the fact that it offers a technology by which, for the first time, instruction really can be geared to the specific abilities, needs, and progress of each individual.(7)

Even as some were looking to the computer to bring about the long awaited revolution in education, others were warning of the dangers of their use.(8)

And Felix Kopstein in 1971 was already predicting that "with an extremely high probability of being correct sometime during the next decade, computer aided or assisted or administered instruction will be pronounced a costly failure."(9)

One of the earliest and most persistent of the pioneers who sought to turn the potential of computers into reality was Donald Bitzer at the University of Illinois. In 1960 he began work on what was to become the PLATO system. It was in part because the history of PLATO is almost co-terminus with the history of the effort to use computers in education, that we examined it in some detail earlier in this report.

XIII. CONCLUSION: WHITHER EDUCATIONAL TECHNOLOGY?

Having just considered the brief modern history of educational technology that spans at most three decades, it is well to remember that the Model T Ford was produced for two decades from 1908 to 1928. During that period the groundwork was being laid for the transformation of American society by the motorcar, but how many in 1928 foresaw how extensive that transformation was going to be?

One often hears references to today's computers as being "Model Ts" in comparison with what is yet to come. Similarly, we are probably in the Model T stage of their impact on society and, particularly education. The superiority of the automobile to the horse as a mode of transportation did not have to be demonstrated by studies. Duston Hueston, president of NICAT, regularly tells audiences that no amount of effort to improve horses or horse technology, such as improved wagons, would have saved the horse as a competitor of the automobile. The one technology had simply reached the limit of its capability while the other was just beginning to show its potential.

(It is not irrelevant to note that there are more horses in America today than at the time the internal combustion engine was our primary means of transportation and source of agricultural power. Does this foretell a time when there will be more humans teaching than there are today, but performing a differing role than that of today's teachers?)

It is hard to believe that a tool as powerful as the computer, one that is becoming indispensable in so many areas of life outside of education, will not before long transform education and training and become as indispensable there as it is in other areas.

What will assure high levels of application of technology in education will be the coming convergence of all the media important in delivering instruction. Text, data, graphics, pictures (still and moving) and sound will soon all be available through one device and those devices will be linked through local and worldwide communication networks so that information and coursewares that is available anywhere will easily be available everywhere.

Thus the answer to the original question posed by OTA is that there are alternatives to the traditional forms of adult education and vocational training, but it is too soon to say yet which of them are going to prove to be most effective, acceptable to students, instructors and institutions, and economically viable. There are a number of conclusions from the study in which can place a high degree of confidence:

1. No single device or technology will be the answer to all training needs. Those needs and the variability of individuals is too great to expect that any one approach will fit all.

2. Some technologies, particularly those employing microprocessors, will make major contributions to the improvement of instruction.

3. Large investments in development and experimentation will have to be made before those benefits are widely realized.

4. The most effective use of devices for instruction will be in situations where the device itself is the object of instruction, as when computers are used to teach the use of computers.

5. Live instructors will continue to play an important role in instruction, particularly in helping those adults with the greatest difficulty in becoming self-directing learners.

6. The development of effective applications of technology to the instruction of adults will benefit from extensive dissemination of successful practices and from policies both at the institutional and governmental levels that recognize the critical importance of the investment of up-front time and money.

7. Systematic studies to demonstrate the value of particular programs, devices and training strategies will help improve decision making regarding training technologies, but there are no strong incentives for organizations doing training to produce such studies, and their absence will not be a significant barrier to the further development of instructional technologies.

FOOTNOTES

FOOTNOTES.

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13. John F. and Joseph G. Gindele, "Interactive Videodisc Technology and Its Implications for Education," T.H.E. Journal, August 1984, p. 93.

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17. An interesting insight into factors influencing the use of technologies was provided by Inabeth Miller, one of our interviewees. She was shopping for a new car and, knowing that the dealers had the video disk players, she asked in each showroom to see what they had. In the General Motors showrooms noone seemed familiar with the players or had any interest in showing them. In the Ford showrooms, the salespeople always seemed familiar with the machines and were glad to show them. The difference, Ms. Miller discovered, was that on the back of the Ford disks there was a game which everyone enjoyed playing. So, without special training, Ford had found a way to get people to learn to use the machines and thus to make use of them for their intended puposes.

18. For a comprehensive description and analysis of maintenance simulators in the military see J. Orlansky and J. String, "Cost-Effectiveness of Maintenance Simulators for Military Training," Arlington, VA., Institute for Defense Analyses Paper P-1568, 1981. See discussion of the paper below.

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22. Ibid., pp. 102-103.

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24. Matthew B. Miles, Innovations in Education (New York: Columbia University Press, 1964), p. 657.

25. Ibid., pp. 658-9.

26. David Kelley, "Analysis of Training and Human Resource Development Programs of Companies and Service Organizations Located in the Merrimack Valley of Massachusetts." In progress.

CHAPTER VI. CAI IN ADULT BASIC EDUCATION

1. Elizabeth Buckley and Peter Johnston, "Pilot Project in Computer Assisted Instruction for Adult Basic Education Students, 1982-83," Final Report, Great Neck Public Schools, 1983.

2. Information on Central Piedmont from interviews with Richard H. Hagemeyer, president, and Cynthia Wilson, project director, and from college-supplied documents.

3. The current average number of hours for a student to complete one grade level in reading is 27.9 hours; for math, 23.05 hours. As of June 1984, almost 600 persons had participated of whom 49% were employed full-time and 9% part-time. 63% had not completed high school; 71% were black; and there were equal numbers of males and females.

4. Norman D. Kurland, Robert L. Purga and William J. Hilton, "Financing Adult Learning: Spotlight on the States" Education Commission of the States Lifelong Learning Project Report, July 1982, p. 41.

FOOTNOTES

CHAPTER VII. TECHNOLOGIES COMPARED.

1. Op.cit., 1979, p.4.

2. Ibid., p. 55.

CHAPTER VIII. EFFECTIVENESS AND SOCIAL INTERACTION.

1. K. Patricia Cross, Adults as Learners (San Francisco: Jossey-Bass, 1981,) pp. 208-209.

2. Cross, op.cit., pp. 210-211.

3. Op.cit., 1979, p. 53.

4. Ibid., p. 54.

CHAPTER IX. INSTRUCTIONAL DESIGN STRATEGIES.

1. In our literature review we found these terms being used and the core ideas being developed in the late sixties, particularly in the writings of Robert Mager, whose name came up frequently when people discussed the origins of present practice. Two others whose articles go back to the early seventies and whom we heard about and then interviewed were Joseph Harless and Robert Carkhuff. (See references.)

2. Joel S. Finlay, "Diagnose Your HRD Problems Away," Training and Development Journal, August 1984, p. 51.

3. Correspondence, August 31, 1984.

CHAPTER XI. EDUCATIONAL CHANGE: BARRIERS AND INCENTIVES.

1. Matthew B. Miles, "Educational Innovation: The Nature of the Problem," in Miles, op. cit., p. 1.

2. Op. cit., p. 649.

3. The Elementary and Secondary Education Act was passed that year with specific funding for innovations (Title III) and for large-scale research and development through regional laboratories (Title IV). That year too saw the establishment in the New York State Education Department of a "Center on Innovation."

FOOTNOTES 8

CHAPTER XII. INNOVATIONS IN EDUCATION: LESSONS FROM HISTORY.

1. B.F. Skinner, "The Science of Learning and the Art of Teaching," Harvard Educational Review, 24:2, 1954, pp. 86-97.

2. Op. cit., p. 97. Quoted by J.A. Kulik and R.L. Bangert-Drowns, "Effectiveness of Technology in Precollege Mathematics and Science Training," Journal of Educational Technology Systems, Vol. 12(2), p. 138.

3. Cited by Orlansky and String, op.cit., 1979, p. A-12.

4. Hearing record, June 1966, pp. 145-150.

5. Kulik and Bangert-Drowns, op.cit., p. 138.

6. Louis Forsdale, "8mm Motion Pictures in Education: Incipient Innovation," in Miles, op.cit., pp. 203-229.

7. "Technology is Knocking at the Schoolhouse Door," A Fortune Magazine Reprint, August, 1966.

8. A.G. Oettinger and S. Marks, Run, Computer, Run: The Mythology of Educational Innovation (Cambridge, MA: Harvard University Press, 1969).

9. F. F. Kopstein, "Why CAI Must Fail!" in L. Lipsitz, ed., Technology and Education (Englewood Cliffs, NJ: Educational Technology Publications, 1971).

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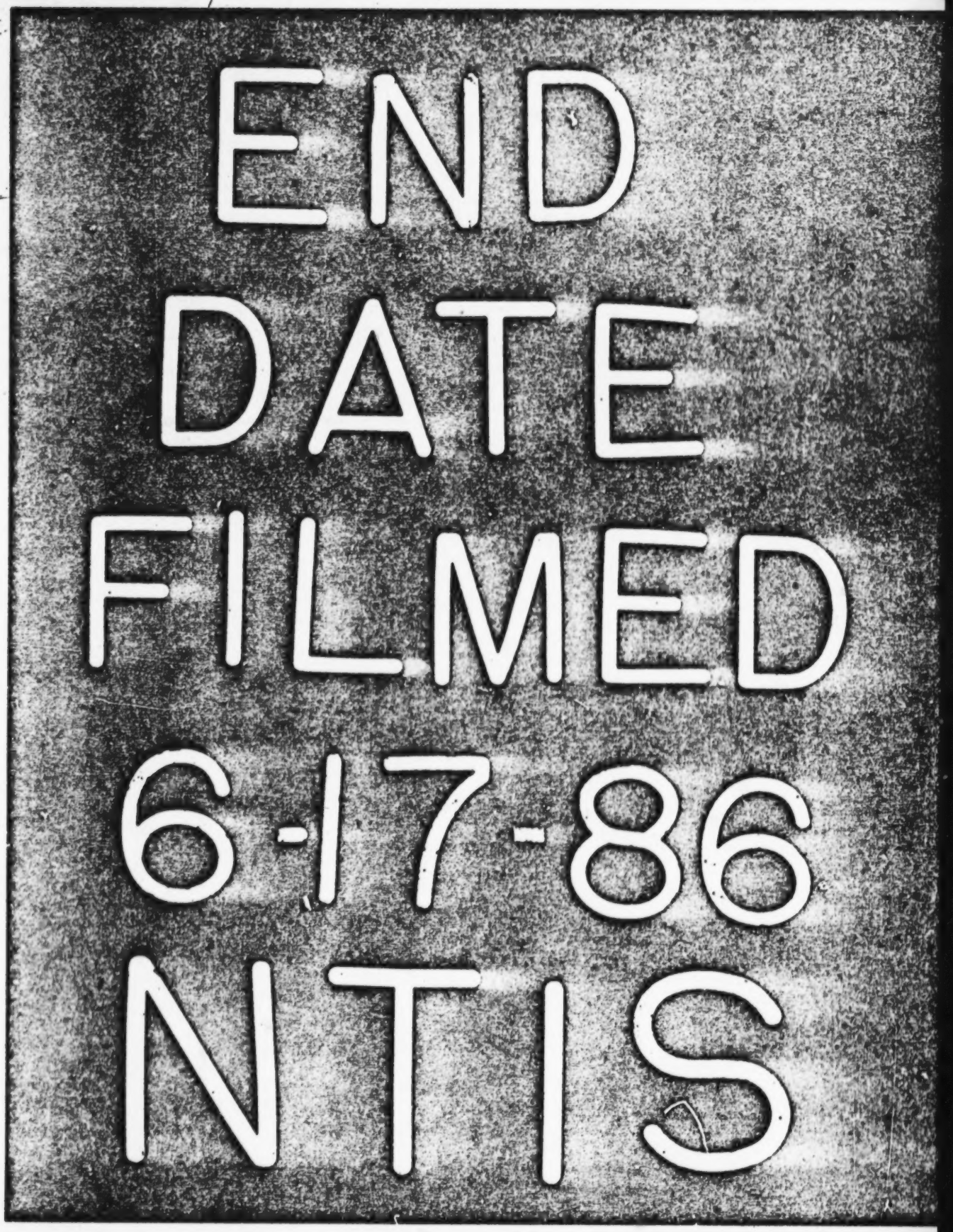
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